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Report of the Biological Survey of Mutsu Bay.

18. Protozoan Fauna of Mutsu Bay.*

Subclass Dinoflagellata;
Tribe Gymnodinioidae

By

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Professor of Zoology, University of California, Berkeley, Visiting Professor in Biology on Rockefeller Foundation, 1930, Tóhoku Imperial University.

(With Pls. I-III and 12 text-figures).

This elusive group of the unarmored Dinoflagellata has not received from investigators of the plankton the attention merited by its wide-spread occurrence and its importance in the ecology of the sea. This omission has occurred largely because of certain technical difficulties in the collection and preservation of the plankton arising from the minute size and the delicacy of these organisms. Most species of this group are less than 50 μ in diameter, the size of the openings in No. 25 silk bolting cloth used in the finest plankton nets. Their minute size, supplemented of their own active movements enables them to escape through the silk so that their representation retained in the plankton is disproportionately small in comparison with the more passive, more angular diatoms. The rush of water through the net as usually handled also destroys the more delicate species.

The usual methods of preservation of plankton, formalin or picroformalin, disrupt or distort these dinoflagellates or render them adherent to other organisms so that they are recongnized with difficulty, if at all, and their numbers are so reduced that their detection, even if preserved, and investigation by cytological methods is rendered doubly difficult. Fortunately their delicacy renders them so transparent in life that much cytological detail can be secured from the living organisms. Their own activities, however, put limits upon this method.

* Contributions from the Marine Biological Station, Asamushi, Aomori-ken. No. 61.

They have mainly disappeared or are encysted in small numbers in plankton standing even for an hour in the laboratory. Further-more and perhaps the main reason for their neglect, they are so active in the normal free-swimming state as often to defy all efforts to get even an ocular micrometer reading of their length, to say nothing of a cytological analysis of the often complex systems of girdle and sulcus on which their classification so completely depends.

The investigator of this very important and morphologically most interesting group is thus forced to collect with care, to search the plankton assiduously for normal specimens, and to work rapidly when a favorable opportunity offers. All too often the most promising material disintegrates under the illumination of the microscope, before a complete analysis can be made. All attempts to study structure satisfactorily in cytologically prepared material have failed except in some of the more rigid genera such as *Gymnodinium* and *Noctiluca.*

Care must always be taken to distinguish the young stages of skeleton-forming Peridinioidea of exuviating genera such as *Peridinium, Pyrophacus* and *Gonyaulax,* from encysted *Gymnodinium.* The undivided skeletal wall of such exuviated individuals is usually close-fitting, even into the girdle and sulcus, and in this state they provide the species of the so-called genus *Glenodinium.* The cyste of true Gymnodinioidae, except in initial stages, does not enter the trough of the girdle, is not as close fitting throughout, and is usually more delicate and of a different optical appearance from these early stages in the development of the skeleton in the Peridinioidea. A familiarity with such exuviating genera in the normal skeletal-bearing phase, always coincident in occurrence with these *Gymnodinium*-like, plateless early stages is invaluable to the student of the Gymnodinioidae. A familiarity with their cell contents is also a safeguard against confusing them with the Gymnodinioidae.

The separation of the zoospores of the Blastodiniidae and possibly of other imperfectly known dinoflagellates, from minute species of *Gymnodinium* and related genera is a difficult task, for whose solutions a knowledge of life histories based on culture will be essential.

The species reported in this paper were observed in the plankton of Mutsu Bay during July 1 — August 20, 1930, but mainly between August 1 and 20. The best material was obtained with a net of

No. 25 silk with low filtration coefficient, in vertical hauls from 30 meters to surface, brought promptly to the laboratory. The list therefore is representative of the midsummer only, but fortunately this is the reason of maximum abundance of this tribe of dinoflagellates. The list is by no means complete as many forms observed, especially the smaller ones, 10-50 μ in length, and the more active ones, have not been determined by me, and the time has been insufficient to give an account of all of the forms seen. However, the list contains the larger species, some of the most abundant, and many species of considerable morphological interest. It is representative enough to reveal the splendid resources of the Asamushi Biological Station for the further study of the pelagic Protozoa.

LIST OF GYMNODINIOIDAE FROM MUTSU BAY.

With records from the Mediterranean, Plymouth, and La Jolla, California.

Species	Mediterranean	Plymouth	La Jolla	Mutsu Bay
1. *Protonoctiluca pelagica* FABRE DOMERGUE	+	+	+	+
2. *Amphidinium inflatum*, sp. nov.	—	—	—	+
3. *Gymnodinium abbreviatum* K. and S.	—	+	+	+
4. " *arcuatum*, sp. nov.	—	—	—	+
5. " *coeruleum* DOGIEL	+	—	+	+
6. " *fusus* SCHÜTT	+	—	+	+
7. " *gelbum*, sp. nov.	—	—	—	+
8. " *heterostriatum* K. and S.	—	+	+	+
9. " *lunula* SCHÜTT	+	+	+	+
10. " *ochraceum*, sp. nov.	—	—	—	+
11. " *simplex* LOHMANN	+	+	+	+
12. " *spheroideum*, sp. nov.	—	—	—	+
13. " *viridescens*, sp. nov.	—	—	—	+
14. *Gyrodinium ascendans*, sp. nov.	—	—	—	+
15. " *citrinum*, sp. nov.	—	—	—	+
16. " *falcatum* K. and S.	+	—	—	+
17. " *ferrugineum*, sp. nov.	—	—	—	+
18. " *flavum*, sp. nov.	—	—	—	+
19. *Cochlodinium flavum*, sp. nov.	—	—	—	+

Species	Mediterranean	Plymouth	La Jolla	Mutsu Bay
20. *Cochlodinium helicoides* LEBOUR	+	+	+	+
21. ,, *radiatum* K. and S.	—	—	+	+
22. ,, *schuettii* K. and S.	+	+	+	+
23. *Polykrikos schwartzii* BÜTSCHLI	+	+	+	+
24. *Noctilluca scintillans* MACARTENY	+	+	+	+
25. *Nematodinium atromaculatum*, sp. nov.	—	—	—	+
26. ,, *partitum* K. and S.	—	—	+	+
27. *Pouchetia hataii*, sp. nov.	—	—	—	+
28. ,, *mutsui*, sp. nov.	—	—	—	+
29. ,, *purpurata* K. and S.	—	—	+	+
30. ,, *reticulata*, sp. nov.	—	—	—	+
31. ,, *rosea* (POUCHET) K. and S.	+	—	+	+
32. *Blastodinium crassum* CHATTON	—	+	—	+
33. *Oodinium poucheti* CHATTON	—	+	—	+
	11	11	15	33

In all 33 species as shown above are listed here. Of these 14 are new. Of these 19 previously described 11 are listed by LEBOUR (1925) in the plankton at Plymouth, 11 were reported by SCHÜTT (1896) or others from the Mediterranean at Naples or elsewhere, and 15 were included in the fauna of the California Current off La Jolla by KOFOID and SWEZY (1921) in their monograph on the Gymnodinioidae.

This list is significant in indicating the cosmopolitan destribution of the Gymnodinioidae and the warm-temperate character of the plankton of Mutsu Bay. Its neritic character is also suggested by absence of *Erythropsis*, *Proterthropsis*, *Torodinium*, the abundance of *Noctiluca*, and some species of *Gymnodinium*. No species of distinctively northern habitat are included in this list, although among the Tintinnoinea identified by us in the plankton of Mutsu Bay are species of *Parafavella* and *Ptychocylis* which are specifically northern or Arctic in their origin or affiliations.

I am indebted to the Rockfeller Foundation for the opportunity, while serving as Visting Lecturer in Biology at Tôhoku Imperial Unversity, of making this investigation, to Professor SHINKISHI HATAI,

founder and Director of the Asamushi Biological Station for facilities generously made available for this study, to Assistant Professor S. KOKUBO for the benefit of his extensive knowledge of the local plankton, and to Mr. YOSHINE HADA for effective assistance in finishing my sketches for reproduction as illustrations.

Subclass DINOFLAGELLATA BÜTSCHLI

Mastigophora with two differentiated flagella and permanently beaded chromatin threads in the nucleus.

Order DINIFERIDEA DELAGE and HÈROUARD emend. KOFOID and SWEZY.

Dinoflagellates with tranverse girdle and longitudinal sulcus.

Tribe *Gymnodinioidae* POCHE emend. KOFOID and SWEZY

Diniferidea with no exoskeleton of discrete plates, but often with temporary cyst of homogenous structure.

Family **Protonoctilucidae** LEBOUR

Gymnodinioidae with rudimentary girdle and sulcus, flagella anterior (or posterior ?) or ventral; tentacle more or less developed.

Genus PROTONOCTILUCA LEBOUR

Protonoctilucidae with tentacle well developed, anterior (? or posterior); body elongated.

1. **Protonoctiluca pelagica** FABRE DOMERGUE
(Figs. A and B)

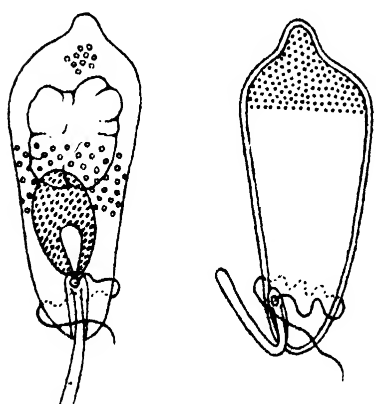
Pelagorhynchus marina PAVILLARD (1917), PP. 238–241, figs. 1–9.
Protodinifer tentaculatum KOFOID and SWEZY (1921) PP. 112–115, pl. 7, fig. 74, fig. R, 2.

Body elongate obovate, or slightly asymmetrically fusiform; widest in the posterior third; length 2.2–2.5 transdiameters; apex asym-

metrically subconical, antapex contracted into a more or less elongated, blunt projection; girdle scarcely developed at all, located within 0.5 transdiameter of the apex; sulcus slightly developed; transverse flagellum as long as the body, usually encircling the anterior end; longitudinal flagellum often carried anteriorly; transverse flagellar pore about 0.5 transdiameter from the anterior end, longitudinal flagellar pore near base of tentacle; tentacle arising from anterior end, slender, cylindrical, about 0.5 transdiameter in length waving slowly, or bent forward suddenly, often bent at right angles; no striae, pellicle punctate.

Cell contents consisting of the antero-dorsally located, elongate ovoid dal nucleus with about 10 chromatin threads across one face; an irregularly contoured, homogeneous, yellowish blue (amyloid?) mass of variable size, in the posterior 0.5 of the body; a cluster of highly refractive oil droplets in the antapical cone; food vacuoles rarely seen; greenish rhabdosomes sometimes found anteriorly radiating from the pore of the transverse flagellum.

Dimensions: — Length, 25–54 μ (LEBOUR, (1925) gives 12–45 μ; transdiameter 13–33 μ; length of tentacle 8–16 μ.



A B

Fig. A and B. *Protonoctiluca pelagica* FABRE DOMERGUE.
A. Ventral view. B. View of left side showing surface stippling of pellicle in the anterior region only. ×800.

Occurrence: — Rather common in the surface and vertical hauls of plankton in Mutsu Bay in July, 1930.

The orientation of this problematical and curious flagellate is based on its functional orientation in locomotion. Morphologically it might be oriented with the tentacle posterior; in which case the tentacle is in a position homologous to that of *Pavillarda*, *Noctiluca*, and *Erythropsis*. The movements of the tentacle are strikingly like those of the tentacle of *Pavilardia* and *Noctiluca*. This proposed orientation is adopted in our figures only.

In my opinion the status of this genus requires further investigation. While at present there is no conclusive evidence of its relationship to *Noctiluca* the tentacle is curiously similar in the two genera in its behavior. Furthermore the very large reserve or amyloid (?) body is rather unique among dinoflagellates, and its range in dimensions is unusual among the smaller Gymnodinioidae. In Mutsu Bay its period of prevalence coincides with that of sporulation of *Noctiluca.* The possibility that it is a stage in the life cycle of *Noctiluca* representing the earliest stage in the life of that species before inflation by hydrostatic vacuoles, should be investigated by culture methods.

Family **Gymnodinioidae** KOFOID

Gymnodinioidae with girdle with 1–4 turns; sulcus spiralling with the girdle beyond 1 turn; no tentacle; no ocellus.

Amphidinium CLAPARÈDE and LACHMANN

Gymnodinioidae with girdle anteriorly located, never posterior to 0.3 total length, often higher dorsally than ventrally; sulcus straight, without apical loop, often deeply impressed with large lateral flaps; epicone relatively quite small.

2. **Amphidinium inflatum,** sp. nov.

(Pl. I, fig. 4)

A large species (for *Amphidinium*); body broadly ellipsoidal, sack-like, flattened ventrally; cross section slightly flattened ventrally; its length 1.52 transdiameters; epicone 0.3 total length ventrally, 0.15 dorsally, dome-shaped, apex flattened; hypocone sack-shaped, subcylindrical in its anterior 0.5, flattened hemispherical antapically, depressed in the mid-ventral region; girdle located in anterior 0.3 of body, horizontal dorsally, broadly V-shaped ventrally, trough deeply incised, with sharp overhanging margins; sulcus extending nearly to the apex on the epicone where it is very narrow, widening below the girdle, where it is also straight, but terminating 0.16 total length above the aboral end; anterior flagellar pore at junction of proximal end of girdle with the sulcus, posterior flagellar pore about the mid-

dle of the postangular sulcus; no striae; pellicle double-contoured, distinct.

Cell contents consisting of the large, ellipsoidal, transversly placed, centrally located nucleus with about 12 transverse, beaded chromatin lines; minute oil globules clustered in the perinuclear cytoplasm; elliptical, plate-like, canary yellow chromatophores in the distal ends of radiating cytoplasmic strands which pass to the subpellicular cytoplasm; a small spheroidal, bluish green amyloid body near the nucleus; large hydrostatic fluid-filled vacuoles surrounding the central cytoplasmic mass; general color tone yellowish gray.

Dimensions: — Length, 47 μ; transdiameter at girdle 30 μ.

Occurrence: — Two individuals observed in the surface plankton of Mutsu Bay, August, 17–18, 1930, in surface temperatures of 25°–25.2°.

Amphidinium inflatum belongs in the non-compressed subgenus *Amphidinium* because of its subcircular cross section. It differs from all other species in the fact that the sulcus does not reach the antapex and from all except *A. fastigium* in the degree of development of hydrostatic vacuoles.

Both specimens observed were very active continuously circling with occasional motor reactions and change of course.

Genus GYMNODINIUM (STEIN) emend. KOFOID and SWEZY

Gymnodinioidae with body without torsion; girdle with not over 1 turn, its displacement not over 0.2 total length; no nematocysts, ocellus, or tentacle.

3. Gymnodinium abbreviatum KOFOID and SWEZY
(Fig. C)

A large species; body elongated ovoidal, with expanded cingular region, its length 1.9–2.0 transdiameters; epicone about 0.33 length of the hypocone, subconical (about 80°), flaring basally, lateral outlines concave, apex broadly rounded; hypocone flaring a little at the girdle, subcylindrical in its anterior 0.5, subconical (about 50°) below with asymmetrically rounded antapex, with the longer extension at the left of the sulcus; girdle a spiral of one turn ascending 20° above the

horizontal in its proximal 0.25, descending 20° in the aboral 0.5 turn, and increasing to 40° in the distal 0.25, displaced 0.4 transdiameter, trough deeply incised with prominent margins; sulcus narrow, straight, extending from apex to antapex where it widens locally; anterior flagellar pore in the proximal end of the girdle, posterior flagellar pore in the sulcus at its junction with the distal end of the girdle, surface distinctly striate with broken lines, about 23 across the ventral face; pellicle thickened and covered with minute bosses.

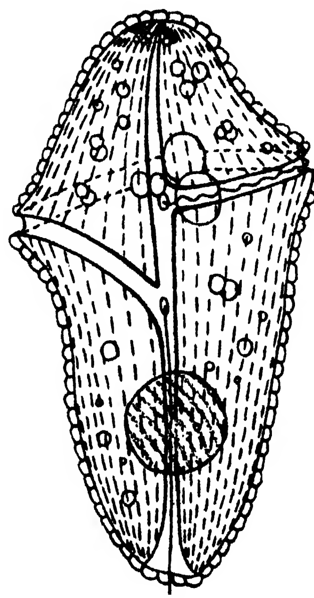


Fig. C. *Gymnodinium abbreviatum* KOFOID and SWEZY. Ventral view. ×800.

Cell contents consisting of the spherical, or broadly ellipsoidal nucleus in the center of the hypocone, with distinct, but fine, moniliform chromatin threads; club-shaped pusules at the pores; spherical oil globules of varying sizes in the periphery; yellowish, or greenish food masses, or food reserves; pinkish vacuoles in the hypocone; cytoplasm very clear, color tone hydrangea pink.

Dimensions: — Length 97–115 μ; transdiameter 50–75 μ.

Occurrence: — Common in plankton of Mutsu Bay, July 1–30, in surface temperature of 16°–25.2°. Not seen in August. This is the commonest species of the Gymnodinioidae in the plankton of Mutsu Bay, with the exception of numerous minute species of uncertain status.

4. Gymnodinium arcuatum, sp. nov.

(Pl. I, fig. 9)

Body stout subellipsoidal in ventral view, with deeply arcuate antapical end; elongate ovoidal in lateral view, its length 1.38 transdiameters and the dorso-ventral diameter 0.88 of the transverse in

the girdle; girdle median in location, its distal end deflected posteriorly for about two girdle widths at an angle of 45°; girdle plane horizontal; body slightly constricted at the girdle whose furrow is narrow and acute in cross section; epicone dome-shaped, its length about 0.88 its greatest transdiameter which is 0.33 of its length above the girdle, its greatest dorso-ventral diameter almost equalling the transverse; apex broadly rounded; hypocone in ventral view subequal to the epicone but deeply indented by a broadly arculate postmargin, about 0.5 transdiameter between the subequal bounding lobes whose apices are equally broadly rounded, its dorso-ventral diameter not exceeding that in the girdle and 0.88 that of the epicone; girdle horizontal, no overlap or displacement; sulcus narrow, invading the epicone for 0.2 its length, flaring in its distal 0.5 to nearly 0.5 the arcuate postmargin; transverse flagellar pore at proximal end of girdle; longitudinal flagellar pore about 0.3 of the distance from girdle to postmargin below the girdle; longitudinal flagellum very long, nearly twice that of the body; numerous longitudinal pellicular striae faintly marked by granular structures.

Cell contents consisting of a spherical nucleus, located at the right of the axis at the level of the girdle; pusule a short, canal near the nucleus; two spherical food vacuoles with light and dark brown contents adjacent to the nucleus; numerous small, spherical highly refractive oil droplets mainly in the epicone; color pale lemon yellow.

Dimensions: — Length, 69 μ; transdiameter 50 μ; dorso-ventral 44 μ; length of longitudinal flagellum 200 μ; diameter of nucleus, 26 μ.

Occurrence: — Rather commen in the plankton of Mutsu Bay, July–August, 1930, at temperatures of 18°–23°.

5. **Gynodinium coeruleum** DOGIEL

(Pl. I, fig. 5)

A large species, body elongated, subconical, its length nearly 2 transdiameters; cross section subcircular, flattened on ventral face; epicone and hypocone subequal; epicone subconical (about 45°) with slightly convex ends and rounded asymmetrical apex; hypocone proximally conical (30°), distally contracting to a subhemispherical form

with concave postmargin at the end of the sulcus, its sides slightly convex; girdle narrow, a descending left spiral of one turn with a displacement of about 0.25 transdiameter, trough deep with sharply defined, double contoured margins, overhang of 0.5 girdle width; sulcus extending from apex to antapex, nearly straight, with a slight sigmoid curve in the intercingular region, very narrow on the epicone, widening on the hypocone especially in its distal half; anterior flagellar pore in the proximal end of the girdle, posterior flagellar pore almost at the distal end of the sulcus; pellicular striae very prominent, 12–14 across the ventral surface from side to side.

Cell contents consisting of an indistinct spheroidal nucleus near the center of the body with faint nuclear membrane; a pyriform amyloid (?) body in the base of the epicone, a cluster of highly refractive, spherical oil droplets in the apical region; a linear pusule connecting the two pores; rows of minute ellipsoidal chromatophores of a cornflower blue color along the longitudinal striae; plasma very clear, of pale Prussian blue color.

Dimensions: — Length, 120 μ; transdiameter, 60 μ.

Occurrence: — One specimen taken in surface plankton in Mutsu Bay, August 16, 1930 in a surface temperature of 26.8°. Drawn from an active individual.

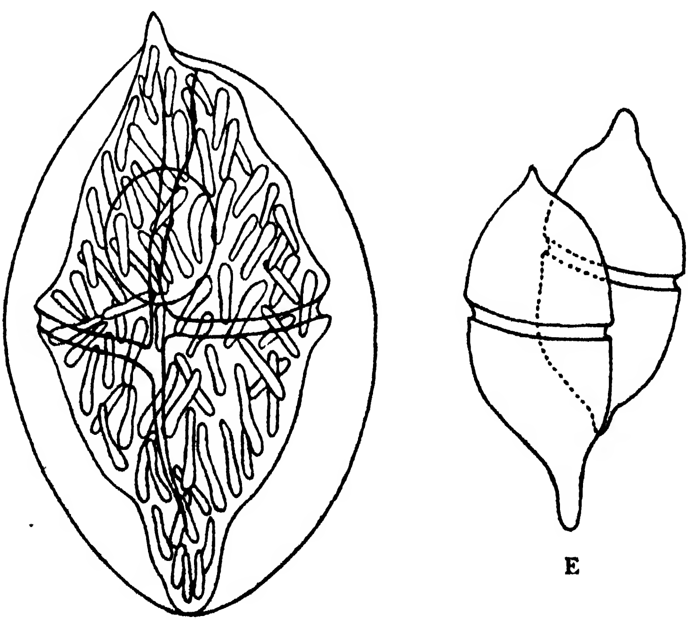
Gymnodinium coeruleum belongs to the striate subgenus *Lineadinium,* and is nearest to *G. costatum* KOFOID and SWEZY in its proportions and shape but differs from it in its blue instead of pink color, in its more contracted epicone, and in a slightly more slender form.

One specimen from Mutsu Bay differs in some particulars from specimens described by DOGIEL. It has fewer striae, the sulcus extends to the apex, and the body is more elongated. It seems probable that the differences are due more to the contracted state of the individuals drawn by him than to specific characters.

Our specimen remained active in a small slender dish for at least three hours moving continuously in characteristic anti-clockwise circles interrupted by frequent motor reactions.

6. Gymnodinium fusus Schütt
(Figs. D and E)

A large species; body asymmetrically fusiform; its length 2.06–2.50 transdiameters; epicone and hypocone subequal; epicone campanulate, flaring at the base, convex above, contracted in the distal 0.4 to a stout cylindrical horn contracting apically to a rounded tip; hypocone less flaring basally, convex subconical (35°), with an oblique (30° below the horizontal) postmargin, sloping from right to left, with a blunt horn 1–2 girdle diameters in length extending near the end of the sulcus on the right side; girdle a descending left spiral of one turn displaced distally about 2 girdle widths with an overhang, its trough deeply incised with acute margins; sulcus extending upon the epicone for 0.7 its length, with a slight sigmoid curve on the hypocone, flaring distally; no striae; cyst inflated ellipsoidal.



D E

Fig. D and E. *Gymnodinium fusus* Schütt.
D. Ventral view, after Schütt (1895, pl. 24, fig. 79 (1)). ×800.
E. Two conjoined individuals in reversed polar relations, probably recent 50 schizonts. Original, Asamushi, 1930.

Cell contents consisting of a spherical nucleus located in the hypocone, with very fine moniliform chromatin lines, about 20 across one face; numerous elongated, ellipsoidal, or comma-shaped, lemon yellow chromatophores scattered throughout the cytoplasm, numerous spherical oil droplets of varying sizes in the periphery; and several subellipsoidal amyloid bodies near the nucleus; cytoplasm dense; general color tone dark lemon yellow.

Dimensions: — Length, 55–63 μ, transdiameter, 27–30 μ. SCHÜTT's figure, length 100 μ, transdiameter, 45 μ.

Occurrence: — In the plankton of Mutsu Bay from 30–0 meters August 9, 1930, in a surface temperature of 22.8°. Two conjoined individuals, connected ventrally with poles in reversed relation remained in this condition from 10 a. m. to 4 p. m., but clearly moribund. They may be sister schizonts still connected, but with one reversing its antero-posterior relations. This seems more probable than conjugation, since sexual reproduction is still problematical in this group of Protozoa, and this reversed position is not suggestive of conjugation. The nucleus of each was in a dumb-bell shape suggesting an advanced stage of mitosis.

7. Gymnodinium gelbum, sp. nov.

(Pl. I, Fig. 1)

A small species; body broadly and slightly asymmetrically elliptical in ventral outline, its length 0.71–0.80 transdiameters; broadly elliptical in cross section; epicone and hypocone subequal; epicone subhemispherical, flattened ventrally, with right shoulder steeper than left; hypocone subhemispherical with concave postmargin, its flat side a trifle longer than the right; girdle median, a descending left spiral of one turn, distally displaced 1.8 its width, trough lightly impressed (in cyst) with indistinct margins (normal?); sulcus not indenting epicone, straight, widening posteriorly; anterior flagellar pore in proximal end of the girdle, posterior flagellar pore near distal end of sulcus; striae not evident; cyst wall closely applied.

Cell contents consisting of an indistinct spherical nucleus located in the epicone; numerous scattered oil droplets; several homogenous greenish amyloid bodies; numerous small, elongated, lemon yellow,

peripherally located chromatophores; a small pusule directed anteriorly from the posterior flagellar pore; plasma dense; general color tone, deep lemon yellow.

Dimensions: — Length, 48–50 μ; transdiameter, 40 μ; dorso-ventral diameter, 30–32 μ.

Occurrence: — Two specimens, both encysted, in surface plankton from Mutsu Bay, August 16, 1930 in a surface temperature of 24.6°.

Gymnodinium gelbum seems to belong to the subgenus *Gymnodinium* without striae. It was difficult to be certain that faint striae were not present. It is nearest in shape to *G. contractum* Kofoid and Swezy, but differs from that species in proportionately larger hypocone, in its greater displacement of girdle, and in its yellow, instead of reddish color.

8. Gymnodinium heterostriatum Kofoid and Swezy

(Fig. F)

A medium-sized species; body subsymmetrically ellipsoidal with slight equatorial expansion; its length about 1.5 transdiameters; epicone and hypocone subequal; epicone with hemispherical apex, becoming convex conical (35°) basally; left side more convex than right; hypocone similar to epicone but less contracted distally and right side more convex than left; girdle a somewhat, low, descending left spiral of one turn, with distal displacement of 1 girdle width and very slight overlap, its trough not deeply impressed, with ridged margins; sulcus narrow, slightly curved to the right in the epicone where it nearly reaches the apex, turning sharply between the overlapping end of the girdle, and terminating at 0.2 the length of the hypocone above the antapex; anterior flagellar pore in the narrowed proximal end of the girdle, posterior flagellar pore midway on the

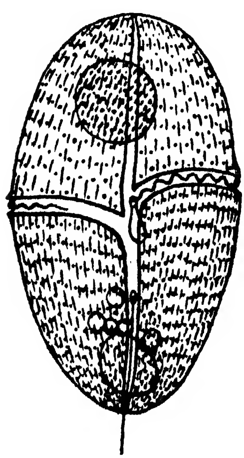


Fig. F. *Gymnodinium heterostriatum* Kofoid and Swezy. Ventral view. After Kofoid and Swezy (1921, Fig. Y, 7). ×800.

hypocone; about 18 striae on the epicone on the ventral face and nearly twice as many on the hypocone; cyst hyaline, thin-walled, applied.

Cell contents consisting of the subspheroidal nucleus in the epicone; a sack-like pusule from the anterior flagellar pore; no chromatophores; minute, periphally located, spherical oil droplets; a dense layer of short rodlets in the periphery; food vacuoles containing other Gymnodinioidae, often greatly distending the body; cytoplasm clear, general color tone pinkish cinnamon.

Dimensions: — Length, 66–85 μ; transdiameter, 48–72 μ.

Occurrence: — A number seen in plankton of Mutsu Bay, July 1–30, in surface temperatures of 16°–25.2°.

This is one of the most cannibalistic species of the genus *Gymnodinium* and accordingly varies in size, somewhat in proportions, and in color, as a result of the amount and nature of its recent feeding.

9. Gymnodinium lunula SCHÜTT

(Figs. G. to Q.)

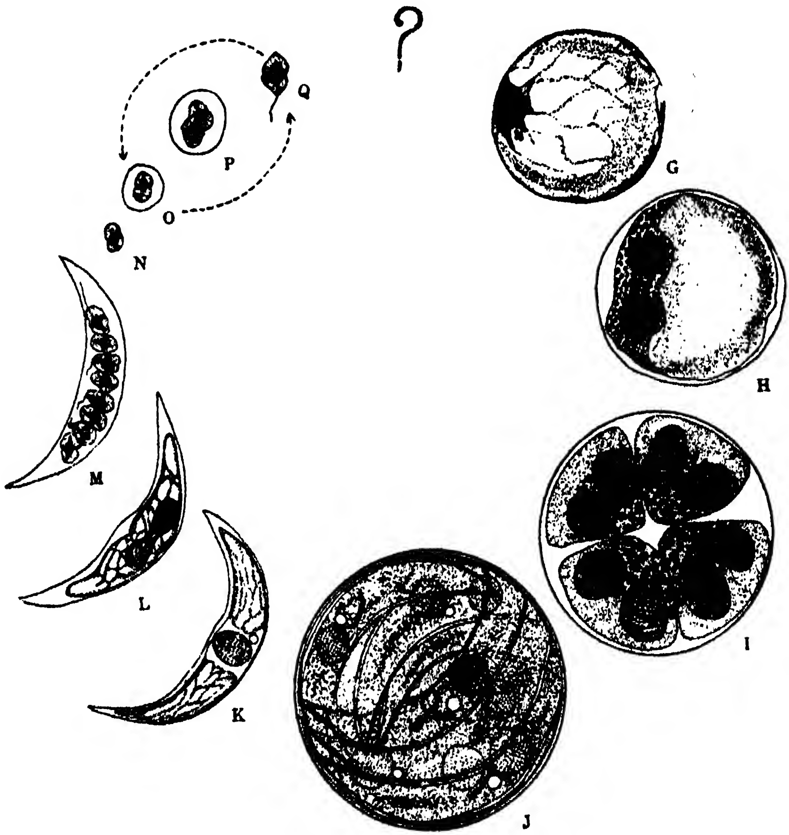
This species exists in the plankton in three forms; a small Gymnodinioid free stage, a large spherical cyst, and a lunate cyst, formed in the succession named except that the connection between the first and second stages is not established.

Free-swimming stage with subequal epicone and hypocone; its length 1.3 transdiameters; cross section subcircular; apex ovoidal, antapex hemispherical with slightly concave postmargin; girdle median, a descending left spiral, displaced distally nearly its own width, rather narrow and deeply impressed with angular margins; sulcus indenting the epicone for 0.35 its length, straight, widening antapically; flagellar pores both anterior near the ends of the girdle; no striae; color tone, greenish yellow.

Cell contents consisting of the ellipsoidal, obliquely placed nucleus in the epicone; a cluster of oil droplets near the apex; small linear, or sinuous, pale yellow chromatophores; length, 22 μ, transdiameter 17 μ.

Spherical cyst neatly spherical with firm, well-developed entire cyst wall; its contents consisting of a thin protoplasmic layer on the

inner face of the cyst, locally thickened about the laterally located nucleus which is ellipsoidal with typical moniliform chromatin threads; numerous linear, or sinuous chromatophores; numerous oil droplets;



Figs. G. and Q. Life cycle of *Gymnodinium lunula* SCHÜTT. After KOFOID and SWEZY (1921, p. 64, fig. I (1-11) from DOGIEL, 1906, pl. I).
Pyrocystis stage, G.-M. *Gymnodinium* stage, N.-Q. G. Large globular form. Resting spore? H. Formation of first cleavage nuclei. Protoplasmic body shrinking away from cyst wall. Primary cyst stage. I. Second cleavage with fourth division of nuclei completed. J. Formation of cresent-shaped spores. Secondary cysts. K. Single spore released from the cyst. L. Begining of division of the spore. M. Completion of spore divisions with the formation of eight *Gymnodinium* individuals. N. *G. lunula* escaped from cyst. O. Formation of tertiary cyst. P. Division of encysted individuals. Q. Individual escaped from cyst. Encystment may take place, repeating O-Q many times before the next stage is begun. The change from Q to G is unknown. ×220.

a huge central vacuole filling most of the cyst; no pusules noted; diameter, 80–155 μ. This stage undergoes cell division passing through the 2–4–8–16 cell stages in rapid succession, the last elongating with the cyst into a stout form of the lunate stage.

Lunate stage also encysted with a rigid, thick, entire wall, when fully formed, the outer convex contour forms nearly a perfect arc of 180°, the innner concave, being somewhat flattened, and sometimes having a local bulge at the center; tips blunt; length, 80–155 μ.

Cell contents as in the spherical cyst, except that the chromatophores are elongated and anastomosing beyond the central mass, the oil droplets numerous and widely scattered; the hydrostatic vacuole in two parts filling the plasma sack of the two horns; a girdle-like constriction is sometimes formed about the equator as division approaches. This stage by three successive divisions forms 8 small *Gymnodinium* stages which escape as the free stage.

Occurrence: — Rather common in the spherical and lunate stages in the plankton of Mutsu Bay in July–August, 1930, at surface temperatures of 16°–26°.

10. **Gymnodinium ochraceum,** sp. nov.

(Pl. I, fig. 6)

A medium-sized species; body broadly ovoidal, considerably flattened dorso-ventrally, its length 1.2 transdiameters; dorso-ventral diameter 0.82 transverse diameter; epicone and hypocone subequal; epicone in ventral view subconical (70°) basally, rounding broadly at the apex, with convex sides; hypocone subhemispherical with a shallow concavity in the sulcul region of the postmargin; girdle a descending left spiral with a distal displacement of one girdle width, without overhang, trough very shallow without distinct margins (in cyst); sulcus not seen to extend upon the epicone, straight, flaring distally; no striae; cyst wall loosely applied but not distended.

Cell contents obscured by depth of color and crowded chromatophores especially in the hypocone, consisting of a small, centrally located, indistinct, spheroidal nucleus whose structure was obscured; a large, subovoidal, yellowish amyloid body in the center of the hypocone; numerous small oil droplets; a large number of ellipsoidal

and disk shaped, ochraceous chromatophores in the periphery and heaped about the nucleus and amyloid body; plasma (in epicone) remarkably transparent; general color tone dark ochraceous.

Dimensions: — Length, 65 μ; transdiameter, 55 μ; dorso-ventral diameter 45 μ.

Occurrence: — One specimen taken in the surface plankton of Mutsu Bay, August 16, 1930 in a surface temperature of 26.8°.

This species is a member of the subgenus *Gymnodinium*, without striae. It is nearest *G. flavum* but differs from that species in larger size (65 μ as against 26–35 μ), and is ochraceous instead of strontium yellow in color and the girdle is not so far anterior.

11. Gymnodinium simplex LOHMANN

(Pl. I, fig. 8)

A minute species of simplest structure; body broadly ellipsoidal, length about 1.5 transdiameters; cross section broadly ellipsoidal both apices subhemispherical; girdle equatorial, horizontal, not displaced; trough shallow, without angled margins; sulcus not deepened, not extending on the epicone; no striae; flagella not seen.

Cell contents consisting of relatively large, centrally located nucleus with clearly defined chromatin granules; large, flattened, dark yellow chromatophores in the periphery, or grouped posteriorly, four to many in number, when numerous, small and subcircular.

Dimensions: — Length, 10–20 μ; transdiameter 6–13 μ.

Occurrence: — In alimentary canal of *Mytilus dunkeri*, *Pecten yessoensis* and in that of trochophore larvae in the plankton from Mutsu Bay, July–August, 1930, also free in the plankton, especially in August, at surface temperatures of 22.4°–26°.

12. Gymnodinium sphaeroideum, sp. nov.

(Pl. I, fig. 7)

A small species; body asymmetrically spheroidal; epicone and hypocone equal, each a hemisphere; epicone with a slightly flattened apex; hypocone with left side a trifle more distended distally than the right side; girdle median, of 1 turn, without displacement, trough shallow, with indistinct margins (in cyst); sulcus extended on the

epicone to the flattened apex, narrowing distally and broader in the postcingular region, extending a little beyond the antapex; anterior flagellar pore in the proximal end of the girdle, posterior flagellar pore about 1.5 girdle widths from the apex (in vertical distance); no striae; cyst wall delicate, closely applied.

Cell contents consisting of a transversely elongated, broadly dumb-bell-shaped, median nucleus extending almost the entire width of the body with concentric lines of coarse chromatin beads at the left and at right angles at the opposite end; a central spheroidal mass of highly refractive spherules (fat?); two large greenish yellow amyloid bodies in the hypocone; a few minute oil droplets in the periphery; a thick layer of crowded, ellipsoidal, canary yellow chromatophores in the periphery; radiating strands between this layer and the central mass.

Dimensions: — Length, 37–54 μ; diameters, 37–54 μ.

Occurrence: — Three specimens taken in plankton at 3 meters, August 18, 1930, off Futagojima, in Mutsu Bay in a surface temperature of 26.8°.

Gymnodinium spheroideum belongs in the non-striate subgenus *Gymnodinium* and is similar in shape to *G. ovulum* but differs from that species in the presence of chromatophores, holophytic nutrition and larger size, 37 μ as against 28 μ. Somewhat similar forms were rather frequently seen during July–August. There seems to be no connection of this species with any exuviating, Peridinoid species in occurrence or appearance.

13. **Gymnodinium viridescens,** sp. nov.

(Pl. I, fig. 2)

Body very broadly ellipsoidal, bifurcated antapically, its length 1.16 transdiameters; cross section broadly ellipsoidal, the dorso-ventral diameter about 0.8 the transverse; ventral face flattened, sulcus deeply impressed; girdle horizontal, not displaced, located about 0.4 of the total length from the apex, its trough angular, not very deeply impressed; sulcus slightly indenting the spicone, very deeply impressed; postmargin deeply notched, the right and left horns subequal, the depression between the two extending upon the dorsal face; no striae;

pellicle distinct and heavy (but no sign of plates or skeleton).

Cell contents very dense, obscuring the structure; nucleus small, spheroidal, mainly in the epicone, with very faint moniliform chromatin threads; two large, irregularly ovoidal, nearly homogeneous, highly refractive amyloid bodies near the nucleus; a layer of small, spheroidal oil droplets in the periphery and several irregular, large, bright green chromatophores in either horn; color tone, pale greenish; no pusules seen.

Dimensions: — Length, 30 μ; transdiameter 25 μ; dorso-ventral diameter, 20 μ.

Occurrence: — One specimen taken in a vertical haul from 30 meters in Mutsu Bay, in a surface temperature of 23.6° on August 11, 1930.

This species belongs in the subgenus *Pachydinium* because of its thick pellicle. It is significant that the only other bifurcated species in the genus, *G. bifurcatum*, also belongs in the same subgenus with our species. The layer of subpellicular droplets is also more or less developed in other species of *Pachydinium*. It is the smallest species in that subgenus. It stands apart from all other species in the character of its bifurcation.

That it is not a stage in the development of *Peridinium* is apparent by the character of the pellicle, the absence of any evidence of an apical pore, and the fact that no green species of *Peridinium* occurred in Mutsu Bay during the months of July and August.

Genus GYRODINIUM Kofoid and Swezy

Gymnodinioidae with girdle a descending left spiral of more than 0.2 total length; no nematocysts, ocellus, or tentacle.

14. **Gyrodinium ascendans**, sp. nov.

(Pl. II, fig. 11)

Body ellipsoidal, circular in cross section, its length 1.62 transdiameters; apex and antapex subequal, the latter slightly more flattened: girdle oblique, 40° above the horizontal plane, its proximal end ascending sharply in the first 90° of the circumference, turning rather abruptly at the left margin obliquely posteriorly across the

dorsal face and continuing in the distal 90° at an angle of about 15° below the horizontal plane; trough rather deeply impressed; sulcus extending from near the apex to the antapex, curving above the girdle slightly to the right side, widening towards the postmargin; anterior flagellar pore at the proximal end of the girdle below the middle of the body, posterior flagellar pore almost at the postmargin; no striae.

Cell contents consisting of the relatively large, elongated ellipsoidal nucleus with rather coarsely beaded chromatin threads, about 20 across one face, scattered, linear, lemon yellow chromatophores beneath the pellicle clustered in the antapical region; a few slender linear rhabdosomes in the antapical region; a few greenish homogeneous oil droplets seen; general color pale yellow.

Dimensions: — Length, 60 μ; transdiameter, 37 μ; length of cyst, 65 μ.

Occurrence: — One specimen taken in a vertical haul from 30 meters in Mutsu Bay, on August 11, 1930 in a surface temperature of 23.6°.

This species belongs in the subgenus *Laevigella* since it lacks surface striae. It differs from all species in that subgenus, however, in having the proximal end of the girdle ascending steeply in its proximal 90°. In this peculiarity it resembles *G. pingue* SCHÜTT belonging to the striate subgenus *Gyrodinium*. However, it differs from *G. pingue* in a greater prolongation of the steep ascent, in less obliquity of the distal quadrant of the girdle, in a more posterior position of both flagellar pores and in a greater anterior extension of the sulcus.

During the first minutes of observation our specimen shed its rather closely applied cyst wall, the process being entirely completed within less than one minute. Excystement began with the rounding up of the cell and loss of furrows followed by protrusion of a narrowed posterior process, an active protoplasmic movement, followed by a more gradual extrusion of the rest of the cell through the rent in the wall, and a final shrinkage of the cyst in a wrinkled cap about the apex. Immediately a second, closely applied cyst wall was formed about the escaped cell which did not resume the normal form with girdle and sulcus.

15. **Gyrodinium citrinum**, sp. nov.

(Pl. II, fig. 10)

Body elongated ovoidal, somewhat contracted anteriorly to a broadly rounded point and wider posteriorly; its length about two transdiameters and its dorso-ventral diameter greatest in the hypocone at the level of the distal end of the girdle, equalling the transdiameter throughout; epicone equals the hypocone in length, flattened ventrally, more convex dorsally, and contracts more abruptly in its anterior third; in ventral view the apical region forms a cone of about 95° with slightly convex sides and rounded apex; hypocone hemispherical in its distal half in ventral view, but contracting to a blunt point in lateral view in a cone of about 90°, becoming more convex towards the girdle and slightly flatter on the ventral than on the dorsal face; girdle forming a descending left spiral with a distal displacement of 0.33 total length and an overhang of 0.2 transdiameter, steepest in its proximal and distal parts; furrow very deeply impressed and the anterior lip overhanging somewhat; sulcus extending over the posterior two-thirds of the total length; its anterior end continued above the girdle onto the epicone for a girdle width; the intercingular portion forming nearly 0.5 its length, and deflected to the left in the middle part in a sigmoid curve; below the distal end of the girdle widening asymmetrically to the right; pellicle distinctly visible though not so much thickened as in the subgenus *Pachydinium* of *Gymnodinium.*

Cell contents consisting of the spherical, centrally located nucleus with faint, moniliform chromatin threads; a small number of greenish, longitudinally placed, linear rhabdosomes; apical and antapical masses of dark orange color; a few irregular, yellowish chromatophores beneath the pellicle; and numerous, spherical, peripherally located oil globules of greenish blue color; general color tone of the organism lemon yellow.

Dimensions: — Length, 54 μ: transdiameter, 27 μ; diameter of nucleus, 14 μ.

One specimen was taken in the surface plankton, July 11, 1930 in Mutsu Bay, off the Biological Station in a surface temperature of 18.4°.

This species is near *Gymnodinium flavescens* but differs from it

in slightly greater size, less overhang of girdle, greater steepness of proximal part of the girdle, rather more tapering epicone, and greater rotundity of the hypocone which results in a greater contrast between these two regions of the body.

16. Gyrodinium falcatum KOFOID and SWEZY
(Pl. II, fig. 14)

Gymnodinium fusus SCHÜTT, 1896. partion, pl. 25, fig. 81 (1–3), his pl. 24, fig. 79 (1–3) is *Gymnodinium fusus*.

A large species of fusiform shape; body elongated, tapering subequally at the ends, arched ventrally; its length (in free stage) 3–4 transdiameters, in the cyst, 2 transdiameters; dorso-ventral diameter at girdle only slightly less than the transdiameter; epicone and hypocone subequal; epicone subconical with convex sides basally changing from 45° to 70° distally, constricted within a transdiameter of the girdle into an apical horn, bulging distally, with a truncate apex; in the free phase this horn is strongly curved sinistro-ventrally, nearly a transdiameter in length and is swollen slightly near the apex, in the cyst it is shorter and stouter, about 0.5 transdiameter in length, with more lateral bulge; hypocone basally similar to the epicone, with a terminal horn of cylindrical shape, about a transdiameter in length, curved sinistro-ventrally, with contracted, pointed tip; girdle a descending left spiral of one turn, displaced distally about 0.5 transdiameter with no overhang, trough deep, rounded, margins rounded; sulcus slightly sigmoid, 1.0–1.3 transdiameters in length, invading the epicone for 0.3 transdiameter and terminating on the hypocone in about the same distance below the distal end of the girdle; anterior flagellar pore in the proximal end of the girdle, posterior flagellar pore in the distal end of the sulcus; no striae; cyst wall shaped to the configuration of the body but elongated at the ends.

Cell contents consisting of a dense peripheral layer of elongated ellipsoidal to short rod-shaped, deep ochraceous chromatophores which obscure the nucleus; numerous large spheroidal oil globules; general color tone dark ochre to light brown.

Dimensions: — Length, (between apices, not along curvature) 63–90 μ; transdiameter, 24–32 μ; SCHÜTT's 1895, pl. 24, fig. 79, is 100 μ long.

Occurrence: — One individual taken in the plankton of Mutsu Bay from 30–0 meters on August 16, 1930 in a surface temperature of 25.3°.

We have referred this specimen to *Gyrodinium falcatum* because of its chromatophores and girdle. It is much more elongated than the encysted, and presumably contracted specimen figured by SCHÜTT (1895, pl. 25, fig. 81 (2)).

17. Gyrodinium ferrugineum, sp. nov.

(Pl. I, fig. 3)

A small species; body asymmetrically ovoidal; its length 1.23 transdiameters; cross section subcircular; epicone slightly less than the hypocone; epicone subhemispherical with a minute apical elevation, left shoulder more elevated than the right; hypocone asymmetrical, subconical, (40°) right side convex distally, left flattened, antapical end slightly flattened with trace of a sulcus embayment on the postmargin; girdle a descending left spiral of one turn, displaced distally a little more than 0.5 transdiameter, descending rather uniformly at about 20° below the horizontal, trough very deeply impressed with sharp overhanging margins; sulcus extended in a slender straight channel on the epicone almost to the apex, with a sigmoid curve in its intercingular course, widening below its junction with the distal end of the girdle; anterior flagellar pore in the proximal end of the girdle, posterior flagellar pore 1.5 girdle widths from the postmargin; no striae.

Cell contents consisting of the relatively large ellipsoidal nucleus, detected with difficulty, 0.6 by 0.4 transdiameter, with its long axis deflected dextro-sinistrally; an elongated, ellipsoidal pusule deflected to the left from the posterior flagellar pore; numerous minute oil droplets distributed along both sides of the distal end of the girdle and about the posterior part of the sulcus; two large irregular, subellipsoidal, greenish yellow amyloid bodies in the left part of the hypocone; numerous rusty brown, elliptical, plate-like chromatophores crowded in the epicone; general color tone in the epicone marked rusty brown, in the hypocone greenish gray.

Dimensions: — Length, 32 μ; transdiameter, 26 μ.

Occurrence: — One specimen taken in the plankton collected at 3 meters below the surface in Mutsu Bay, August 17, 1930, in a surface temperature of 25.8°.

Gyrodinium ferrugineum belongs to the subgenus *Laevigella* lacking striations. It is nearest to *G. melo*, resembling that species in proportions, but has less torsion in the intercingular sulcus, no overhang of the ends of the girdle and a postmarginal embayment. It also differs in color, being ferruginous instead of green. The sharp limitation of chromatophores to the epicone is unusual, and the color rather exceptional in the genus.

18. Gyrodinium flavum, sp. nov.

(Pl. II, fig. 12)

A small species of asymmetrical biconical shape; its length 2.13 transdiameters; epicone distinctly wider than hypocone, asymmetrically convex conical (60° in lateral view) with the angular apex tilted ventrally, the dorsal face more convex than the almost straight ventral face; hypocone subconical (32°) with broadly rounded antapex; girdle a descending left spiral, displaced posteriorly 0.45 total length, making 1.25 turns, descending 20° in the first 0.5 turn, and 30° in the remaining 0.75, trough very deeply impressed with overhanging margins; sulcus narrow, not invading the epicone, with torsion 0.25 turn, its distal end below the distal end of the girdle straight; anterior flagellar pore in sulcus opposite the proximal end of the girdle, posterior flagellar pore in the distal end of the sulcus; surface coarsely striate throughout, some lines more distinct than others.

Cell contents consisting of an indistinct nucleus, centrally located, spherical, with faint chromatin lines; a small pusule posteriorly directed from the anterior flagellar pore and a larger one postero-dorsally directed from the posterior flagellar pore; a small cluster of black pigment granules in the postcingular angle and several others near the distal end of the girdle; no chromatophores; no rhabdosomes; numerous minute oil droplets; plasma very clear; general color tone grayish dark yellow.

Dimensions: — Length, 68 μ; transdiameter, 32 μ.

Occurrence: — A single very active specimen taken in surface

plankton in Mutsu Bay, August 15, 1930, in surface temperature of 22.6°.

Gyrodinium flavum belongs in the striate subgenus *Gyrodinium* and differs from all other species in proportions. Its wider epicone and asymmetrical apex are unlike these regions in other species. It is nearest to *G. truncus* KOFOID and SWEZY but differs from that species in more slender proportions, greater torsion of sulcus, less pointed antapex, and the presence of black pigment.

Genus COCHLODINIUM SCHÜTT

Gymnodinioidae with body with torsion of 1.5–4.0 turns; sulcus often with an apical loop; no nematocysts, ocellus, or tentacle; usually holozoic, usually highly colored.

19. Cochlodinium flavum, sp. nov.

(Pl. II, fig. 13)

A small species with an asymmetrical, deeply constricted ellipsoidal body 1.9 transdiameters in length; apex flattened dome-shaped, antapex subhemispherical; dorso-ventral diameter about equal to the transverse; girdle a descending left spiral of 1.75 turns, horizontal in the proximal 0.5 turn, descending at 45° in the next 0.5 turn, and again horizontal in the next 0.5 turn, and at about 20° below the horizontal in the distal 0.25 turn, rather deeply constricting the body, with a deep trough with overhanging precingular margin; sulcus making 1 full turn in a steep descending left spiral, with a short apical loop of 0.25 turn reaching the apex and a longitudinal course to the postmargin behind the junction with the distal end of the girdle, rather deeply constricting the body in its intercingular region; anterior flagellar pore at the proximal end of the girdle, posterior flagellar pore midway between the junction of the distal end of the girdle and sulcus and the postmargin; no striae.

Cell contents consisting of a large, broadly ellipsoidal nucleus in a postmedian location, with beaded chromatin network; a slender pusule joining the two flagellar pores; several large, spheroidal oil globules; a peripheral layer of stout, radially arranged rhabdosomes; a crescentic reddish body somewhat like a simple ocellus near the

postmargin; numerous discoidal, yellow chromatophores, peripherally located; general color tone lemon yellow. Our specimen was enclosed in a detached cyst wall within which a second cyst was beginning to from and detach itself.

Dimensions: — Length, 32 μ; transdiameter, 20 μ.

Occurrence: — One specimen was taken in the surface plankton in Mutsu Bay, August 12, 1930 in a surface temperature of 25.4°. Also in vertical plankton from 30–0 meters, August 13. This specimen had a red granule of spherical form in the epicone.

Cochlodinium flavum belongs to the subgenus *Glyphodinium* and is near to *G. convolutum* but differs from it in smaller size, yellow instead of greenish color, and in having a longer, more deeply constricted body.

20. Cochlodinium helicoides Lebour
(Fig. R)

Cochlodinium helix Schütt, *partim*, 1895, pl. 24, fig. 77 (5) (wrongly cited by Lebour, 1625, p. 62, as "pl. 22".

Cochlodinium helix, Kofoid and Swezy, 1921, *partim*, pl. 9, fig. 92, text-fig. HH8; text (pp. 370–371) includes Schütt, 1895, pl. 24, figs. 77 (1–5) in *C. helix*.

A small species; body asymmetrically ovoidal, with marked antapical asymmetry, but not deeply constricted, its length 1.5 transdiameter; apex convex subconical (about 80°), antapex bilobed, the lobe protuberant; epicone somewhat greater than the hypocone; girdle a descending left spiral of 1.5 turns, rising 10° in its proximal 0.25 turn descending nearly 45° in the dorsal 0.5 turn and about 10° with increasing steepness distally in the next (ventral) 0.5 turn, increasing in the last 0.25 turn, trough moderately impressed; sulcus with an apical loop of 0.5 turn reaching the apex, its proximal part quite oblique (20°), the intercingular section 45° with a total of 1 complete turn; pores at junction of girdle and sulcus; no striae.

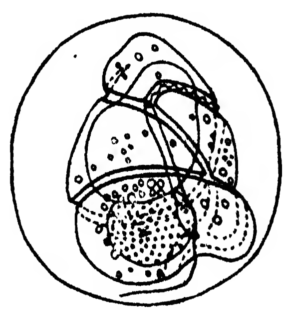


Fig. R. *Cochlodinium helicoides* Lebour (1925), Ventral view, after Kofoid and Swezy (1921, fig. HH8). ×800.

Cell contents consisting of ellipsoidal, or spheroidal nucleus centrally located, with distinct chromatin threads; thickly strewn, elliptical, light orange, peripherally located chromatophores; pusules from both pores; cytoplasm moderately clear, color tone dark yellow.

Dimensions: — Length, 36–54 μ; transdiameter 24–36 μ; cyst up to 80 μ.

Occurrence: — Several individuals in the plankton of Mutsu Bay from 3 meters off Futagojima, August 18, 1930 in a surface temperature of 25.4°.

21. Cochlodinium radiatum KOFOID and SWEZY

(Fig. S)

A medium sized species; body rotund ellipsoidal, its length 1.28 transdiameters; epicone considerably greater than hypocone; apex subhemispheroidal; antapex hemispheroidal, but slightly modified by girdle and sulcus, the upper part of the hypocone bulging slightly; girdle a descending left spiral of 2 turns, subhorizontal in the first 0.75 turn, then at 35°–30° for 0.5 turn, steepening out distally to 45° except near its end (20°), trough narrow, rather deeply impressed with distinct margins; sulcus extending on the epicone only half way to the apex, with torsion of 1 complete turn, quite narrow and constricting the body somewhat, oblique in the postcingular section; anterior flagellar pore opposite the proximal end of the girdle and posterior flagellar pore opposite its distal end; no striae; cyst not seen.

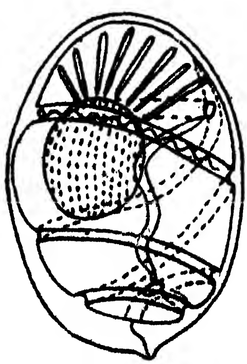


Fig. S. *Cochlodinium radiatum* KOFOID and SWEZY. View of right side. Original, Asamushi, 1930. ×800.

Cell contents consisting of the elongated ellipsoidal nucleus located in the right central region, with fine moniliform chromatin threads; a slender pusule connecting the two pores; no oil droplets; a group of radiating elongated, tapering, greenish rhabdosomes, in the epicone; diffuse reddish violet tone throughout, contracting to splashes of aster purple pigment rather uniformly distributed beneath the

pellicle; cytoplasm transparent, general color tone grayish blue, when the diffused pigment concentrates.

Dimensions: — Length, 68–78 μ; transdiameter, 52–60 μ.

Occurrence: — One specimen taken in the surface plankton of Mutsu Bay, August 8, 1930, in a surface temperature of 24.5°.

Our specimen differed from that figured by KOFOID and SWEZY (1921, pl. 6, fig. 67) in that the color was diffused instead of aggregated in peripheral splashes. The latter condition indicates approaching cytolysis.

22. Cochlodinium schuettii KOFOID and SWEZY
(Fig. T)

Cochlodinium helix SCHÜTT, *partim*, 1895, pl. 24, fig. 77 (6); his pl. 24 figs. 77 (1–4) are *C. helix* (SCHÜTT) KOFOID and SWEZY, *partim*, figs. 77 (5) being *C. helicoides* LEBOUR (1925, pl. 9, fig. 2).

Cochlodinium schuettii KOFOID and SWEZY, 1921, pl. 1, fig. 8, text-fig. HH2.

A medium sized species; body asymmetrically ovoidal, its length 1.5 transdiameters; apex hemispheroidal, antapex asymmetrical, the morphological right side being the longer; girdle a descending right spiral of 1.5 turns, displaced distally about 0.5 total length; trough rather deeply incised, with overhanging precingular margin; sulcus indenting the epicone only (?) 0.5 the distance between girdle and apex and only slightly curved, with a torsion of 0.5 turn and no extension on the opposite face; no striae.

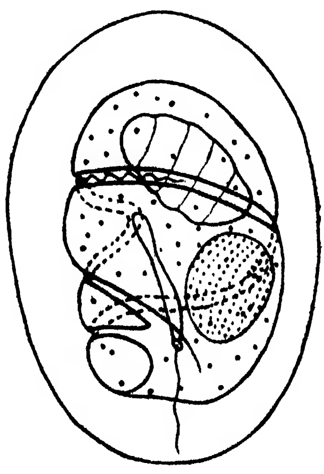


Fig. T. *Cochlodinium schuettii* KOFOID and SWEZY. Dorsal view, after KOFOID and SWEZY (1921, pl. 1 fig. 8). ×800.

Cell contents consisting of the elongated, somewhat twisted, subcentrally located nucleus with about 15 faint, moniliform, longitudinal chromatin threads; peripheral, elongated, slender, lemon yellow chromatophores; peripheral layer of spherical oil droplets; spherical amyloid (?) body; cytoplasm dense, general color

tone lemon yellow.

Dimensions: — Length, 73 μ; transdiameter 50 μ; length of cyst, 105 μ.

Occurrence: — Several individuals seen in the plankton of Mutsu Bay, August 18, off Futagojima from 3 meters in a surface temperature of 25.4°.

Differs from *C. helix* in less antapical asymmetry, less constriction and absence of the aboral lobe. It is larger than *C. helicoides* (52–54 μ) as against 36–45 μ, has less antapical asymmetry, and the twisted sulcus crowds upon the girdle less quickly.

Family **Polykrikidae** KOFOID and SWEZY

Gymnodinioidae with permanent colonial organization with zooids in linear series, but with common sulcus.

Genus POLYKRIKOS BÜTSCHLI

Number of zooids 2–4–8–16, number of nuclei usually numbering 1 to 2, rarely 1 to 4 zooids; holozoic.

23. **Polykrikos schwartzi** BÜTSCHLI
(Fig. U)

A large species, usually multicellular with 2–4–8, or rarely 16 nuclei, representing as many cells in chain formation, the neuromotor system (flagella and girdle, often one generation in advance of the nuclei); a slight constriction between adjacent cells; length (2 cells) –4.5 (8 cells) transdiameters; cross section subcircular; girdle horizontal, not displaced, no overhang, in a median location on each cell; sulcus slightly sigmoid, nearly ventral, enlarged at junction with the girdle, continuous from cell to cell; flagellar pores in sulcus near girdle; no striae.

Cell contents consisting of spherical nuclei, with distinct, spiral, moniliform chromatin threads about 20 across one face; small scattered oil globules; nematocysts 10–20 μ in length scattered through the cytoplasm; food bodies consisting of dinoflagellates, small ova of Metazoa and even small metazoan larvae often distend the body;

cytoplasm hyaline; general color tone greenish grey to a delicate rose.

Dimensions: — Length, 100–140 μ; transdiameter 65 μ.

Occurrence: — A few individuals seen in the plankton of Mutsu Bay, July 22–30, in surface temperatures of 19°–26.4°.

A cosmopolitan species in warm temperate, neritic seas.

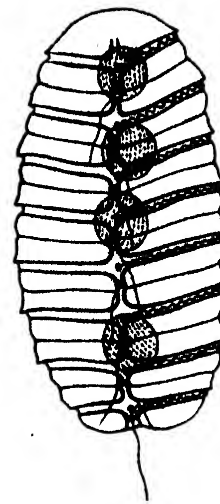


Fig. U. *Polykrikos schwartzi* BÜTSCHLI. Ventral view after KOFOID and SWEZY (1921, fig. F, 4). ×400.

Family **Noctilucidae** SAVILLE KENT

Gymnodinioidae with tentacle at the posterior end of the sulcus; no ocellus; no nematocysts.

Genus NOCTILUCA SURIRAY

Girdle degenerated except for a small remnant of the proximal end, obliterating the separation of the epicone and hypocone, save in the zoospores; hydrostatic vacuoles greatly developed; no transverse flagellum; nutrition holozoic.

24. **Noctiluca scintillans** (MACARTNEY) EHRBG.

(Figs. V–BB)

A very large species; body inflated with hydrostatic vacuoles, broadly reniform to subspheroidal and furrowed ventrally; girdle reduced to a proximal remnant, faintly outlined in the surface structure for less than 0.2 circumference; sulcus forming in the postcingular region the reëntrant cytostome, extended anteriorly in a rigid, straight structure which in small and in collapsed individuals forms a straight axis in the antero-ventral region; transverse flagellum reduced to the mobile tooth at the left of the sulcus near the proximal end of the girdle; longitudinal flagellum arising in the sulcus just below the tooth; prehensile tentacle moving characteristically as in *Pavillardia* and *Erythropsis*, located at posterior end of sulcus; no striae; pellicle firm.

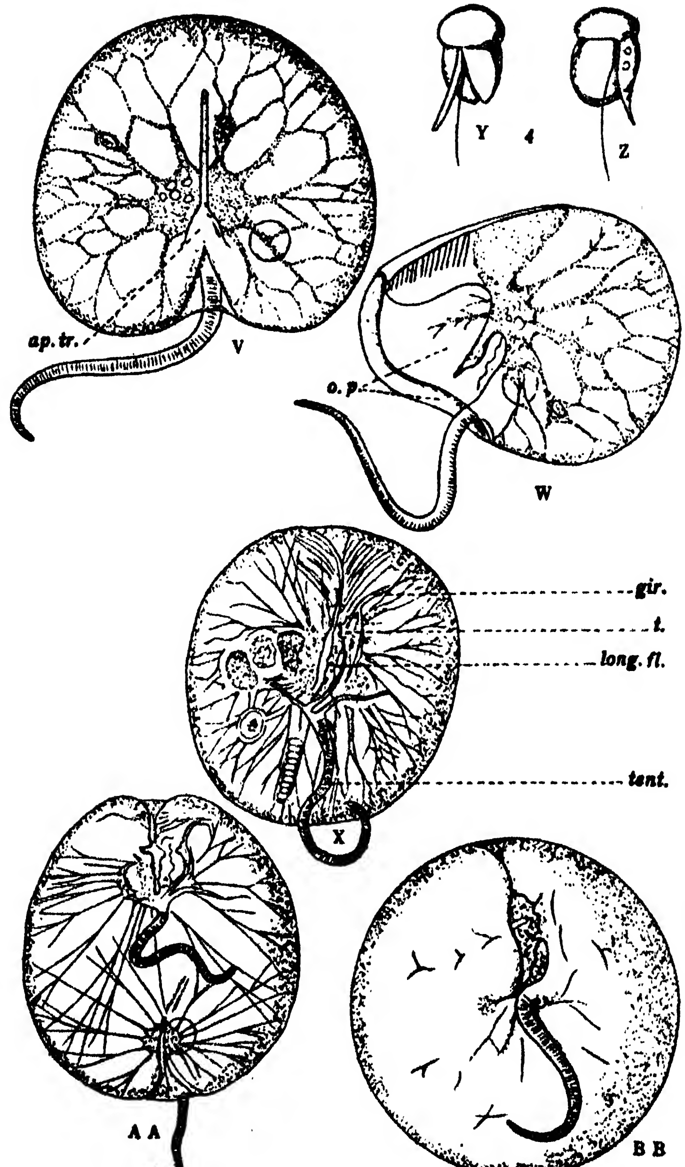


Fig. V–BB. *Noctiluca scintillans* (MACARTNEY). From KOFOID and SWEZY 1921, p. 408, fig. KK (1–6).
V. Dorsal view showing apical trough. After ALLMAN (1872, pl. 18, fig. 1). ×125. W. Lateral view from the left side showing the deep oral pouch. Modified after ALLMAN (1827, pl. 18, fig. 2). ×100. X. Posteroventral view showing sulcus, girdle, undulating membrane or tooth, flagellum and tentacle. The anterior lip is at or near the upper margin of the figure. Modified slightly after ROBIN (1878, pl. 36, fig. 4). ×80. Y and Z. Zoospores. After CIENKOWSKY (1873, pl. 6, figs. 38, 42). ×400. AA. *Noctiluca* in chain at mitosis showing girdle in the anterior schizont. After ROBIN (1878, pl. 41, fig. 24). ×100. BB. Midventral view showing sulcus, rudimentary girdle, transverse flagellum or tooth, longitudinal flagellum and tentacle. Modified after WEBB (1855, pl. 6, fig. 7). Magnification not given. Abbreviations: *ant. l.*, anterior lip; *ap. tr.*, apical trough; *g.*, girdle; *l. fl.*, longitudinal flagellum; *o. p.*, oral pouch; *t.*, tooth or transverse flagellum; *tent.*. tentacle.

Cell contents consisting of a central protoplasmic mass surrounding the nucleus with delicate strands passing to the thin peripheral plasma layer; huge hydrostatic vacuoles inflating the body; numerous spherical, luminescent oil droplets in the central mass, radial strands, and periphery; food masses containing diatoms, ova or larvae of Metazoa, or even entire Copepoda which distort the large body; no chromatophores: small zoospores formed on surface of adult, with longitudinal flagellum, tentacle, and partial girdle.

Dimensions: — Diameter of adult 200–1200 μ; rarely 2000 μ.

Occurrence: — Maximum abundance in Mutsu Bay in May–June (fide Dr. KOKUBO), diminshing rapidly in July, practically absent in August; during periods of greatest abundance forming local shoals by wind action so dense as to discolor the water. Taken occasionally throughout the year in Mutsu Bay.

Family **Pouchetiidae** KOFOID and SWEZY

Gymnodinioidae with ocellus on left side of intercingular sulcus; usually with 1.5 or more turns of girdle, and torsion in the precingular, and postcingular sections of the sulcus; posterior border of sulcus often mobile, but no permanent tentacle; holozoic; usually brightly colored.

Genus NEMATODINIUM KOFOID and SWEZY

Pouchetiidae with nematocysts.

25. **Nematodinium atromaculatum**, sp. nov.

(Pl. II, fig. 15)

Body subellipsoidal, its length 1.7 transdiameters; dorso-ventral diameter 0.7 of the transverse; epicone subhemispherical anteriorly, hypocone more pointed in the antapical region; ventral face flattened and deeply furrowed by sulcus; girdle a descending left spiral of about 1.25 turns, displaced posteriorly at its distal end for nearly a transdiameter, its trough deeply impressed with some overhang of its anterior edge; sulcus extending anteriorly above the girdle for at least one girdle width, deeply impressed in a groove in the flattened

ventral face, with a torsion of about 0.25 turn; anterior flagellar pore in the proximal end of the girdle, posterior flagellar pore below the distal end in the sulcus; no pellicular striae.

Cell contents consisting of the large, anteriorly located, flattened broadly ellipsoidal nucleus with very clear, moniliform chromatin threads, about 15 across one face; four fully developed, elongated cylinndrical nematocysts radiating from the right ventral face of the nucleus near the anterior flagellar pore (and centrosome?) and two smaller partially developed ones in our specimen; ocellus located below the proximal end of the girdle, consisting of a four segmented line of homogeneous, greenish gray lens bodies, pointed antero-dextrally, and two small, sooty black pigment granules adjacent to its base, no red core seen; several small, much reduced food bodies; pusules not seen; pigment granules of sooty black color very uniformly spaced over the whole body beneath the pellicle, about 14 across the apex from girdle to girdle and 10 along the precingular margin in lateral view, granules slightly larger and more numerous in epicone than in hypocone; no chromatophores; cytoplasm very transparent, with a slight olivaceous tint.

Dimensions: — Based on contracted individual; length, $80\,\mu$; transdiameter $48\,\mu$; dorso-ventral diameter $35\,\mu$.

Occurrence: — Description taken from a specimen in a surface plankton collected at 8 p.m. August 11, 1930 in Mutsu Bay in a surface temperature of 22°. Individuals, presumably of this species repeatedly seen in the week of July 23–30 in plankton from Mutsu Bay.

Nematodinium atromaculatum differs from all other species in its pigmentation. Its ocellus has less pigment than any other species except *N. torpedo*, and its girdle has less torsion than elsewhere in the genus. It is about the same size as *N. armatum* but its ocellus is much less developed, lacking the concentric lens and red core of that species.

Nematodinium atromaculatum is an exceedingly active species, ceaselessly moving so that it is wholly impossible to get a camera drawing. The specimen on which the description is based was observed for about 30 minutes under the cover glass. It did not once cease for more than a few seconds at a time the characteristic rotation,

circling locomotion, interrupted by repeated motor reactions during this period. At the close it suddenly stopped, abruptly contracted, ruptured at the anterior flagellar pore and deliquesced in a few seconds except for a disorganized mass of protoplasm containing the pigment granules and the nematocysts. These did not discharge but slowly disintegrated. The two large pigment granules grew progressively lighter in color internally but remained black on their periphery.

26. **Nematodinium partitum** KOFOID and SWEZY
(Fig. CC)

A medium sized species; body elongate ovoidal; deeply constricted; length 1.7 transdiameter; epicone and hypocone subequal; apical region asymmetrically hemispherical, prolonged and flattened on the left face; antapical region truncated with a projecting, low dome-shaped lobe at the left below the last turn of the sulcus; intercingular area bulging laterally; girdle with 1.25 turns of a descending left spiral, horizontal in its proximal 0.5, descending at 45° in the next 0.5 and slackening to 20° near its distal end, constricting the body, with deeply incised trough with sharp margins, its posterior displacement a little more than 0.5 total length; sulcus with an apical loop of 0.5 turn not reaching the apex by 1.5 girdle widths joining the girdle at 0.3 total length from apex, intercingular region nearly 0.5 total length, with a torsion of nearly 0.5 turn, its junction with the distal end of the girdle on the dorsal side at 0.2 total length from antapex; no striae.

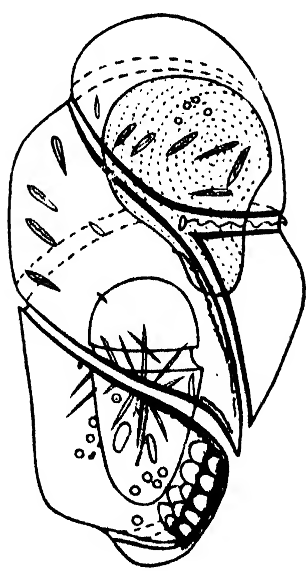


Fig. CC. *Nematodinium partitum* KOFOID and SWEZY. Ventral view, after KOFOID and SWEZY (1921, fig. MM). ×800.

Cell contents consisting of an anteriorly located pyriform or ovoidal nucleus with faint, spiral chromatin

threads; numerous (15) scattered nematocysts distributed mainly in the anterior half of the body, directed antero-dorsally, the longest 0.16 transdiameter in the girdle in length; scattered oil droplets mainly near the two apices; a cluster of radiating rhabdosomes in the posterior region; a large food vacuole opposite the intercingular sulcus containing a partially digested *Gymodinium;* an ocellus of the diffuse type at the left of the distal part of the sulcus, elongated dorso-ventrally, consisting of a distributed lens of 15–20 hyaline spheroidal bodies, in 2–3 rows, of greenish yellow color, embedded in a diffuse melanosome from which slender strands extend along the margins of the sulcus and the girdle; pusules not seen; general color tone pale rose; usually seen in a delicate closely enveloping cyst.

Dimensions: — Length, 91 μ; transdiameter, 52 μ.

Occurrence: — Recorded frequently in the plankton of Mutsu Bay, July 23–30 1930, in surface temperatures of 19°–26.4°. Reported by KOFOID and SWEZY (1921) from the California Current off La Jolla.

Genus POUCHETIA SCHÜTT emend. KOFOID and SWEZY

Pouchetiidae with no nematocysts.

27. **Pouchetia hataii**, sp. nov.

(Pl. III, fig. 16)

A small species with an ellipsoidal body, 1.3–1.7 transdiameters in length; circular in cross section; apex and antapex broadly rounded; girdle a descending left spiral of 1.25–1.40 turns, descending slightly in the proximal 0.25 turn, steeply (45°) in the next 0.5 turn, about 20° below horizontal in the next 0.5 turn, beyond which it shortly joins the sulcus, rather deeply impressed with precingular overhang, but the body not deeply constricted by it, displaced distally 0.5 length of the body; sulcus with an oblique apical loop and a total torsion of 0.5 turn, crowded against the girdle posteriorly by the large ocellus; no striae.

Cell contents consisting of the ellipsoidal nucleus with very distinct chromatin threads; food balls; a well developed ocellus with a condensed, dark brown pigment mass enclosing a large red sensory core in front of which is a slender pillar-like lens body of several segments,

faintly divided, located at the left of the intercingular sulcus; general color tone clear rose.

Dimensions: — Length, 70 μ; transdiameter, 45 μ; length of cyst, 102 μ.

Occurrence: — One specimen in vertical plankton from 30–0 meters in Mutsu Bay, August 13, 1930 in surface temperature of 23.8°.

Distinguished from *P. rosea* by its larger size, 70 μ instead of 44–58 μ; dark instead of red pigment mass, and non-truncated antapical end. The torsion and structure of the ocellus are, however, those of *P. rosea*.

28. **Pouchetia mutsui**, sp. nov.

(Pl. III, fig. 21)

Body ellipsoidal, its length 2 transdiameters; cross section nearly circular, apical end somewhat narrower than the antapical; girdle making 1.2 descending left turn, displaced distally 0.8 transdiameter in the antapical direction, its anterior margin slightly overhanging, and its trough rather deeply impressed; sulcus much elongated anterior to the flagellar pore, reaching almost to the apex, making 1.5 turns anterior to its junction with the girdle, and continuing the spiral direction for only about 0.2 turn between the anterior and posterior flagellar pores, a total of 1.7 turns in its entire course; anterior flagellar pore 0.4 total length from the anterior end, posterior pore a little more than a girdle width above the postmargin; no surface striae.

Cell contents consisting of a very large, anterior located, broadly ellipsoidal nucleus with about 25 moniniform subparallel chromatin threads across one face; no nematocysts; an ellipsoidal, yellowish brown food body near the center; a highly developed ocellus located in the angle below the proximal end of the girdle adjacent to the sulcus, consisting of a carbon black, flattened hemispherical pigment mass with two short amoeboid processes extending on to the base of the cylindrical, elongated, hyaline, homogenous lens body, partially constricted into the linear segments and a terminal button; no trace of red core visible through the black pigment; rufous pigment granules and threadlets in the peripheral cytoplasm rather uniformly distributed over the entire surface with a tendency to larger sizes near

the anterior edge of the girdle; no pusule present in the encysted specimen observed; no flagella were present in the cyst; color tone light red.

Dimensions: — Length, 88 μ; transdiameter, 50 μ; largest diameter of nucleus, 33 μ; width of pigment mass, 33 μ; length of cyst, 126 μ.

A single specimen was taken in a vertical haul from 30–0 meters in Mutsu Bay August 11, 1930, in a surface temperature of 23.6°.

29. **Pouchetia purpurata** KOFOID and SWEZY

(Pl. III, fig. 20)

A medium sized species; body ellipsoidal to elongated ellipsoidal, or ovoidal, its length 1.40–1.75 transdiameters; epicone slightly greater than hypocone; apex hemispherical, antapex similar or asymmetrically distended to the right of the distal end of the sulcus, according to the point of view; girdle a descending left spiral of 1.4 turns, with a distal displacement of 0.5–0.6 total length, trough not deeply impressed, with arching precingular margin; sulcus extending from apex to antapex, with a total torsion of 1.2–1.4 turns, of which nearly one turn may be in the apical loop, probably changing with contraction; no striae.

Cell contents consisting of the centrally, or anteriorly located, ellipsoidal nucleus with distinct chromatin threads; radiating rhabdosomes of greenish color in the antapical region; minute oil droplets in the periphery, food balls of varying sizes and contents; an ocellus somewhat of the diffuse type, with a brownish black melanosome from which amoeboid, granular strands pass out especially along the edges of the sulcus and girdle, located at the left of the distal end of the sulcus, with a lens body of greenish, hyaline color, segmented in 3–5 sections, distally breaking up into spherules and sometimes with an imperfect enclosing sheath of the same substance as an added lamella; sensory core not seen; additional pigment granules are found along the pre- and postcingular margins; no chromatophores; cytoplasm clear, color dahlia purple, aggregating in a peripheral net of granular threads as disintegration approaches.

Dimensions: — Length, 80–88 μ; transdiameter, 52–57 μ.

Occurrence: — One specimen taken in the plankton from 3 meters

off Futagojima, August 18, 1930, in a surface temperature of 26.8°.

This specimen was enclosed in a somewhat distended hyaline cyst. During first two hours of observation the pigment became more aggregated, the body rounded up somewhat, and the lens body underwent some amoeboid deformation and a slight deflection and by the end of four hours entirely disappeared. Toward the end of the period a second cyst wall was detached from the pellicle and began to distend and the first one burst and shriveled up.

Pouchetia mutsui is one of the most highly specialized species of the subgenus *Pouchetiella* in the torsion of the anterior end of the sulcus and in the integration of the ocellus. It is most like *P. atra* KOFOID and SWEZY in structure of the girdle and sulcus, but is larger (88 μ as compared to 64 μ), has more rotundity, the ocellus is much farther anterior and its pigment mass is much larger. Its reddish pigment also differentiates it from the bluish-green *P. atra*.

30. Pouchetia reticulata, sp. nov.

(Pl. III, figs. 18 and 19)

A small species with ellipsoidal body, rather deeply constricted; length 1.7 transdiameters; apex and antapex broadly rounded; girdle a descending left spiral of 1.25 turns, displaced distally 0.75 transdiameter, ascending in the proximal 0.25 turn about 45°, descending in the next full turn about 25°, its trough deeply impressed with well developed margins; sulcus from apex to antapex, with long apical loop of 0.5 turn with an intercingular torsion of about 0.25 turn and continuing to the antapex or the left lateral margin; anterior flagellar pore at the anterior end of the intercingular sulcus, about 0.35 total length from the apex, posterior flagellar pore below the distal end of the girdle; no striae; cyst wall closely applied, hyaline.

Cell contents consisting of an elongated, reniform, centrally located nucleus with many distinct chromatin granules arranged locally in spiral series; a cluster of linear rhabdosomes in the antapical region; a large yellow ochre food body below the distal end of the girdle; a group of small oil droplets in the apical region; and an ocellus of the non-integrated type of remarkable structure consisting of a very black pigment net work over the left posterior region from the proximal

end of the girdle to the antapex located in the periphery under the pellicle, slowly amoeboid, forming a heavy net work of irregular and changing mesh with outlying lines on the edge of sulcus and girdle; below this net of pigment a row of four highly refractive lens bodies lying parallel, subspheroidal, homogeneous, roughly parallel to the course of the lower part of the sulcus; a linear group of canary yellow chromatophores posterior to the lens bodies; a large amyloid body posterioly located no striae.

Dimensions: — Length, 65 μ; transdiameter, 40 μ; length of cyst, 70 μ.

Occurrence: — One specimen taken in a vertical plankton from 30–0 meters on August 13, 1930 in Mutsu Bay in a surface temperature of 23.8°. Another seen in the last week of July in plankton from Mutsu Bay.

As this organism became moribund the pigment lost its characteristic pattern and ran together in droplets of varying sizes, revealing a few rose-colored droplets. The lens bodies deliquesced quickly.

Pouchetia reticulata belongs to the subgenus *Pouchetia* with non-integrated ocellus. It differs from all species in the genus in the remarkable pigment network of exceptionally large size.

31. **Pouchetia rosea** (BOUCHET) KOFOID and SWEZY

(Pl. III, fig. 17)

A small species; body ellipsoidal (in cyst); its length 1.3 transdiameters; epicone greater than hypocone; apex and antapex hemispherical; girdle a descending left spiral of 1.5 turns, displaced distally nearly 1 transdiameter, descending uniformly at about 20° below the horizontal, its trough scarcely impressed (in cyst), with indistinct margins; sulcus with antapical precingular loop of nearly one turn crossing the apex and a torsion of nearly 0.5 turn and a short (?) postcingular course; anterior flagellar pore in the proximal end of the girdle, posterior flagellar pore near the antapex; no striae; cyst wall hyaline, closely applied.

Cell contents consisting of the much elongated, ellipsoidal, subvertical nucleus with distinct, beaded chromatin threads running spirally lengthwise; a relatively huge ocellus located at the right of the distal

part of the intercingular sulcus, consisting of a dense, hemispheroidal brick red pigment mass containing a central, flattened spheroidal carmine red sensory core, and a lens body of hemispheroidal shape, greenish blue color, with two partially developed lamellae added on one side; axis of the ocellus directed anteriorly, cytoplasm clear bluish gray with no trace of pigment except for two small black granules along the sulcus and girdle; three amyloid bodies near the center, numerous minute posteriorly located oil globules; no food vacuoles.

Dimensions: — Length, 44 μ; transdiameter, 33 μ; diameter of melanosome, 15 μ.

Occurrence: — One specimen found in surface plankton of Mutsu Bay, August 18, 1930, in a surface temperature of 25°.

Our description and figure are taken from an encysted and rounded-up individual.

Family **Blastodiniidae** Kofoid and Swezy

Gymnodinioidae with parasitic aflagellate phase, and typical *Gymnodinium*-like, free zoospores with girdle, sulcus, and two typical flagella.

Genus BLASTODINIUM Chatton (1920)

Parasitic in the alimentary canal of Copepoda, enclosed in cyst wall with external spinules.

32. **Blastodinium spinulosum** Chatton

Parasitic phase curved, elongated, blunt anteriorly, tapering posteriorly to a point; enclosed in a cyst with a row of spinules in a descending left spiral of about 4 turns; chromatophores yellowish brown, in a peripheral network; zooids *Gymnodinium*-like, body ovoidal, its length 1.2 transdiameters, girdle median, chromatophores ellipitical, plate-like. Parasitic in *Paracalanus parvus*.

Dimensions: — Length of parasitic phase, up to 210 μ; zooid, lengh, 7 μ.

Occurrence: — A species provisionally identified as *B. crassum* was very abundant in the plankton of Mutsu Bay in *Paracalanus* during August, from minute to large intestinal stages.

Genus OODINIUM Chatton

Ectoparasitic on marine Invertebrata, including Copelata, ***Salpa***, Annelida, and Siphonophora, forming stalked, pyriform, or spheroidal unicellular structures, with root-like extensions into the cytoplasm; detaching and forming minute *Gymnodinium*-like zoospores by repeated divisions.

33. Oodinium poucheti Lemmermann

Brownish unicellular stages tentatively referred to this species, with very dense plasma within which the central nuclear area could be indistinctly located, occurred attached to the tail of ***Oikopleura dioica*** (?) during July, 1930, in the plankton of Mutsu Bay. Occasionally these stages were found free in the plankton in early stages of nuclear division.

Dimensions: — Length of attached stage, up about 75 μ.

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EXPLANATION OF PLATES.

PLATE I.

Amphidinium, Gymnodinium and ***Gyrodinium***; ventral views.
All figures made from life by camera lucida. ×800.

Fig. 1. ***Gymnodinium gelbum***, sp. nov.
Fig. 2. ***Gymnodinium viridescens***, sp. nov.
Fig. 3. ***Gyrodinium ferrugineum***, sp. nov.
Fig. 4. ***Amphidinium inflatum***, sp. nov.
Fig. 5. ***Gymnodinium coeruleum*** Dogiel.

Fig. 6. ***Gymnodinium ochraceum***, sp. nov.
Fig. 7. ***Gymnodinium sphaeroidium***, sp. nov.
Fig. 8. ***Gymnodinium simplex*** LOHMANN.
Fig. 9. ***Gymnodinium arcuatum***, sp. nov.

PLATE II.

Gyrodinium, *Cochlodinium* and *Nematodinium* ; ventral views
All figures made from life by camera lucida. ×800.

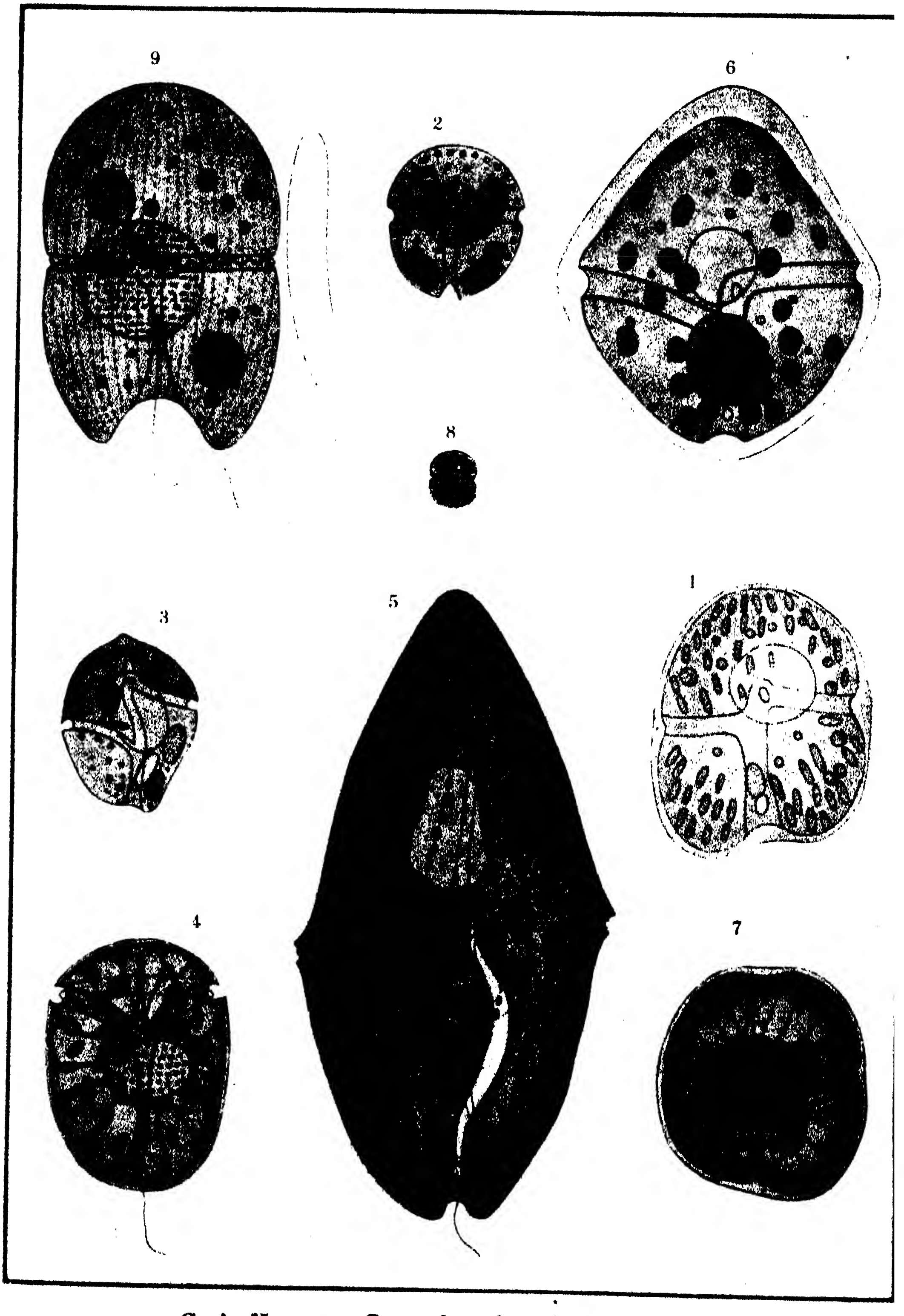
Fig. 10. ***Gyrodinium citrinum***, sp. nov.
Fig. 11. ***Gyrodinium ascendans***, sp. nov.
Fig. 12. ***Gyrodinium flavum***, sp. nov.
Fig. 13. ***Cochlodinum flavum***, sp. nov. View of right side.
Fig. 14. ***Gyrodinium falcatum*** KOFOID and SWEZY.
Fig. 15. ***Nematodinium atromaculatum***, sp. nov.

PLATE III.

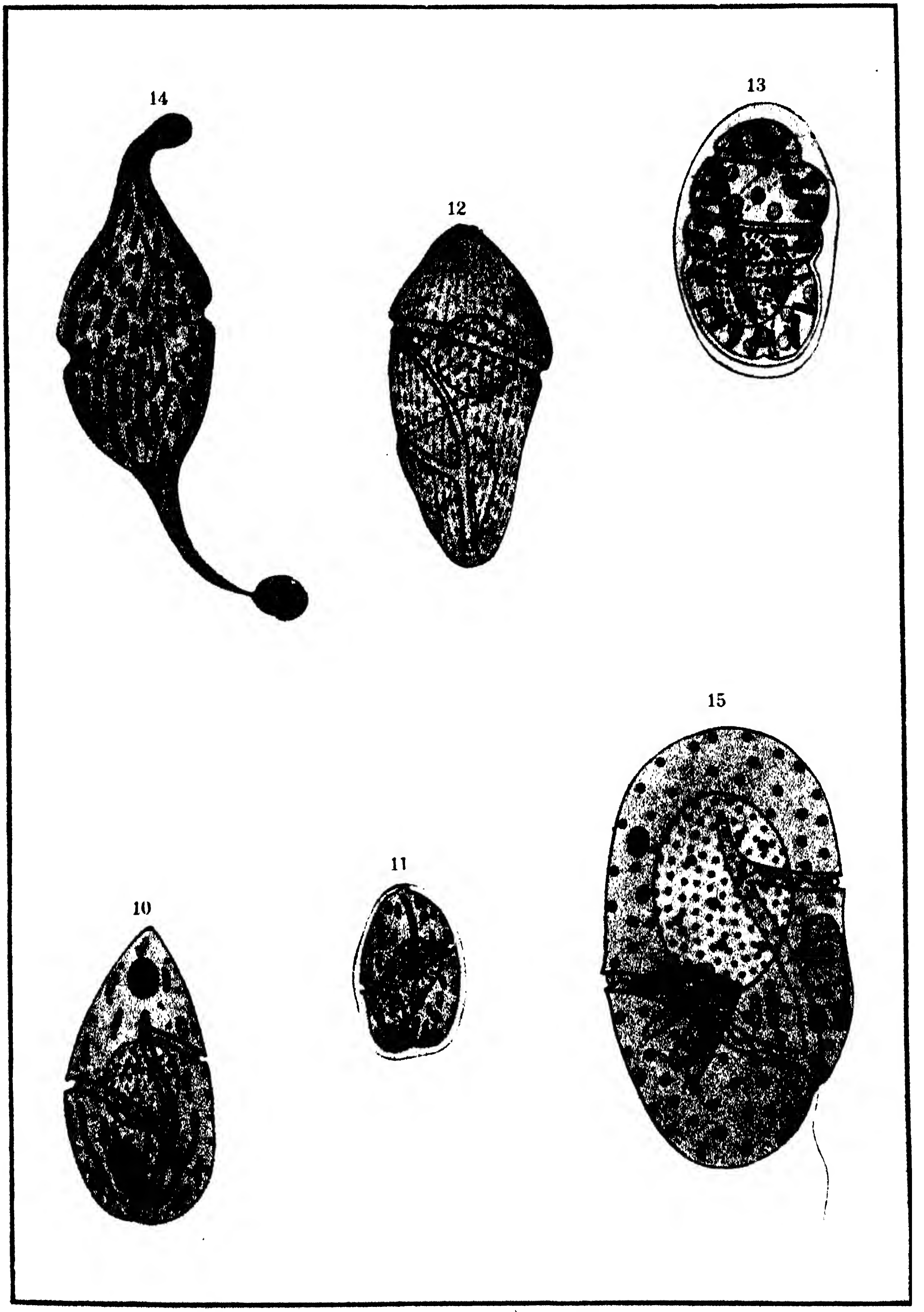
Pouchetia.

All figures made from life by camera lucida. ×800.

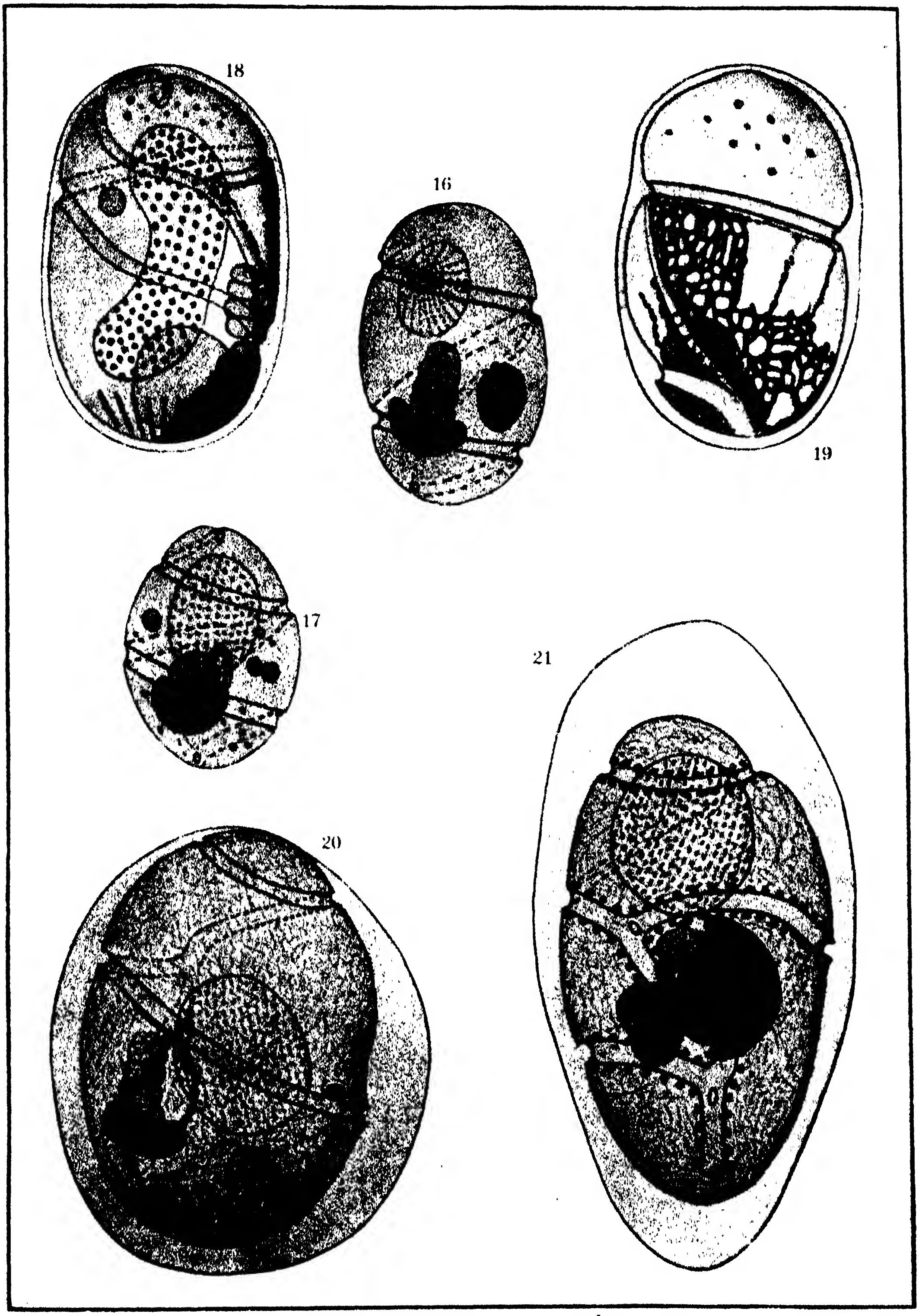
Fig. 16. ***Pouchetia hataii***, sp. nov.; dorsal view.
Fig. 17. ***Pouchetia rosea*** (POUCHET) KOFOID and SWEZY; dorsal view.
Fig. 18. ***Pouchetia reticulata***, sp. nov. Right ventral view.
Fig. 19. ***Pouchetia reticulata***, sp. nov.; view of left side.
Fig. 20. ***Pouchetia purpurata*** KOFOID and SWEZY; dorsal view.
Fig. 21. ***Pouchetia mutsui***, sp. nov.; ventral view.



C. A. Kofoid: Gymnodinioidae of Mutsu Bay.



C. A. Kofoid: Gymnodinioidae of Mutsu Bay.



C. A. KOFOID: Gymnodinioidae of Mutsu Bay.

Report of the Biological Survey of Mutsu Bay.
19. Notes on the Recent Foraminifera from Mutsu Bay.*

By

YOSHINE HADA.

Marine Biological Station of the Tôhoku Imperial University, Asamushi, Aomori-Ken, Japan.

(With 95 text-figures.)

INTRODUCTION.

The present paper deals with the results of observations on the recent Foraminifera from Mutsu Bay. The materials on which the examinations were based, were collected by myself by means of a dredge and a surface net tow during the months of August, 1927 and June, 1928 at about thirty stations, the depth of any one which does not exceed thirty three fathoms.

The classification adopted in this report is that arranged by J. A. CUSHMAN in his excellent work entitled "Foraminifera. Their Classification and Economic Use" (1928).

I have recognized in all one hundred distinguishable forms, the species and varieties numbering respectively ninety four and six. Of the said ninety four species and six varieties, eleven of the species are regarded new to science. Those one hundred forms represented in this paper are contained in forty genera belonging to seventeen families.

Here I wish to express my sincere thanks to Professor S. HATTA under whose supervision the work was carried out. In identification of some of the species I have recieved a great deal of help from Dr. J. A. CUSHMAN and Mr. S. HANZAWA, to whom I am very grateful and make a special acknowledgement here. In publishing the present report I am indebted much to Professor Dr. S. HATAI and

* Contributions from the Marine Biological Station, Asamushi, Aomori-Ken. No. 62.

Professor Dr. S. Hôzawa. For their kindness I thank them heartily.

The following is the list of the species dealt with in the present paper.

DESCRIPTION OF THE SPECIES.

Order FORAMINIFERA.

Family **Astrorhizidae.**

Test free, consisting of a central chamber from which radiate tubular channels to the exterior, either simple or branching; wall with a thin chitinous inner layer on all or part of which is agglutinated arenaceous material; apertures formed by the peripheral ends of the arms or by openings in the peripheral wall.

Genus CRITHIONINA GOËS, 1894.

Test free, spherical, lenticular or variously shaped, interior either with a large chamber and thin wall, usually perforated, or with a

small chamber and thick wall with the communication to the surface by means of numerous branching tubes; wall of sponge spicules and very fine sand, often chalky in appearance, soft, with little cement; color white or grayish.

1. Crithionina pisum Goës.

(Text-fig. 1)

Crithionina pisum, Goës, 1896, p. 24, pl. 2, figs. 1, 2; Flint, 1897, p. 266, pl. 6, fig. 1; Millett, 1899, p. 250, pl. 4, fig. 3; Rhumbler, 1904, p. 230, text-fig. 57; Cushman, 1918, p. 68, pl. 25, figs. 4, 5, pl. 26, figs. 1-3.

Description. — Test usually globular, somewhat compressed; wall thick, subcavernous, consisting of fine sand grains and of sponge spicules agglutinated loosely, giving a chalky appearance, without distinct apertures; surface nearly smooth, slightly uneven; color greyish white.

Text-fig. 1. *Crithionina pisum* Goës. ×20.

Diameter, about 1.50 mm.

Locality. — Off Futagojima, 23 fathoms.

Remarks. — Of this species only a single specimen was found in the material taken from the bottom of Mutsu Bay, and thus rare in this region.

Family Saccamminidae.

Test free or attached, composed typically of a single chamber or occasionally with chamber of the same sort loosely united; wall lined with chitin, the exterior of agglutinated material of various sorts, sand grains, sponge spicules, or other foraminiferal tests; aperture usually single, of various shapes.

Subfamily Psammosphaerinae.

Test without a definite aperture.

Genus PSAMMOSPHAERA F. E. Schulze, 1875.

Test free or attached, globular; wall composed of a thin layer of

chitin with an outer wall of sand grains, mica flakes, sponge spicules, or other foraminiferal tests, firmly cemented; aperture indefinite.

2. **Psammosphaera fusca** F. E. SCHULZE.

(Text-fig. 2)

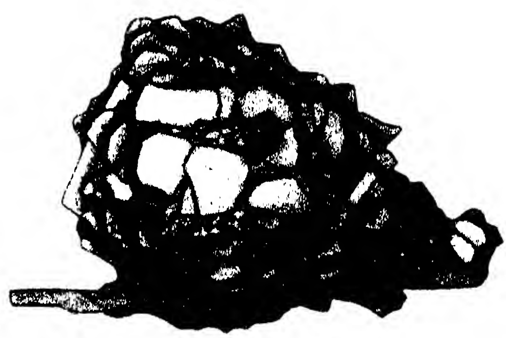
Psammosphaera fusca, F. E. SCHULZE, 1875, p. 113, pl. 2, figs. 8a-f; H. B. BRADY, 1879, p. 27, pl. 4, fig. 1; 1884, p. 249, pl. 18, fig. 1, 5-8; GOËS, 1894, p. 14, pl. 3, fig. 19; CHAPMAN, 1895, p 13; FLINT, 1897, p. 268, pl. 8, fig. 1; MILLETT, 1899, p. 251; KIAER, 1900, p. 14; RHUMBLER, 1904, p. 242, text-fig. 75; SIDEBOTTOM, 1905, p. 1, pl. 1, fig. 1; CUSHMAN, 1910, p. 36, text-figs. 25-28; HERON-ALLEN and EARLAND, 1913 (a), p. 16, pl. 2, figs. 3-6, 10-16; 1913 (c) p. 40; PEARCEY, 1914, p. 1000; HERON-ALLEN and EARLAND, 1915, p. 609; 1916 (a) p. 219; CUSHMAN, 1918, p. 34, pl. 13, figs. 1-6, pl. 14, figs. 1-3; 1920 (b), p. 594; 1921, p. 64; LACROIX, 1929, p. 8, text-figs. 13-15.

Description. — Test free or attached, nearly spherical; chamber built of a single layer of comparatively large and coarse sand grains firmly cemented; aperture indefinite; color varying with the material of the test.

Diameter, 0.60-0.95 mm.

Localities. — Off Yunoshima, 15 fathoms; off Futagojima, 20 fathoms.

Remarks. — I have a few specimens of this species taken from the localities above mentioned, and they are comparatively small in size. BRADY (1884) reported this species from the deep water in the western sea of Japan. Judging from the records referring to this species, this species seems to be widely distributed in the cold waters. But HERON-ALLEN and EARLAND (1915) recorded this species also from the warm and shallow water of the Kerimba Archipelago.



Text-fig. 2. *Psammosphaera fusca* F. E. SCHULZE. ×50.

3. **Psammosphaera parva** FLINT.

(Text-fig. 3)

Psammosphaera fusca (part), H. B, BRADY, 1879, p. 27, pl. 4, fig. 2; 1884, p. 249, pl. 18, figs. 2–4.

Psammosphaera parva, FLINT, 1897, p. 268, pl. 9, fig. 1; RHUMBLER, 1904, p. 242, text-fig. 77; CUSHMAN, 1910, p. 36, text-figs. 29, 30; 1918, p. 35, pl. 12, figs. 4–6; 1920 (b), p. 594, pl. 75, fig. 3; 1921, p. 47, pl. 2, fig. 7.

Description. — Test free or adherent, usually penetrated by a sponge spicule, small, spherical, single chambered, without a definite aperture, being replaced by numerous fine pores scattered among the sand grains; wall composed of sand grains firmly united by the cementing substance; color usually greyish brown.

Text-fig. 3. *Psammosphaera parva* FLINT. ×55.

Diameter, about 0.50 mm.

Locality. — Off Yunoshima, 18 fathoms.

Remarks. — The species is exceedingly rare in Mutsu Bay. The specimens in my hand are of rather small size and none of them was penetrated by a sponge spicule as reported by CUSHMAN (1910) in the case of the specimens which were taken off the southern coast of Hondo from a depth of 943 fathoms.

Subfamily SACCAMMININAE.

Test free, with a definite aperture; wall of firmly agglutinated sand or sponge spicules.

Genus PROTEONINA WILLIAMSON, 1858.

Test free, a fusiform or flask-shaped undivided chamber; wall of coarse sand grains, mica flakes, or other agglutinated material with a thin inner layer of chitin; aperture usually circular, often with a slight neck which may become elongate.

4. **Proteonina difflugiformis** (H. B. BRADY).

(Text-fig. 4)

Reophax difflugiformis, H. B. BRADY, 1879, p. 51, pl. 4, fig. 3a, b; 1881 (b), p. 11;

1884, p. 289, pl. 30, figs. 2–4; GOËS, 1894, p. 26, pl. 6, figs. 196–198; CHAPMAN, 1895, p. 14; GOËS, 1896, p 28; FLINT, 1897, p. 272, pl. 16, fig. 2; MILLETT, 1899, p. 252; KIAER, 1900, p. 15; SIDEBOTTOM, 1905, p. 2; HERON-ALLEN and EARLAND, 1913 (c), p. 42; 1915, p. 612; 1916 (a), p. 222; 1916 (b), p. 40.

Saccammina difflugiformis, EIMER and FICKERT, 1899, p. 671.

Proteonina difflugiformis, RHUMBLER, 1904, p. 245, text-fig. 80a, b; CUSHMAN, 1910, p. 42, text-figs. 40, 41; RHUMBLER, 1911, pl. 2, figs. 7–14; 1913, p. 378; PEARCEY, 1914, p. 1000; CUSHMAN, 1918, p. 47, pl. 21, figs. 1, 2; 1921, p. 49; 1927 (a), p. 130; HADA, 1929, p. 10; LACROIX, 1929, p. 9, text-figs. 16, 17.

Description. — Test free, composed of a single, elongate, oval, or pyriform chamber with a slightly produced tubular neck; wall arenaceous, consisting of sand grains firmly cemented; surface rather rough, occasionally more or less smooth; aperture simple, terminal, rounded; color usually light grey or yellow.

Length, about 0.55 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Mourajima, 20 fathoms; off Futagojima, 15–25 fathoms; between Oshima and Bentenjima, 27–33 fathoms.

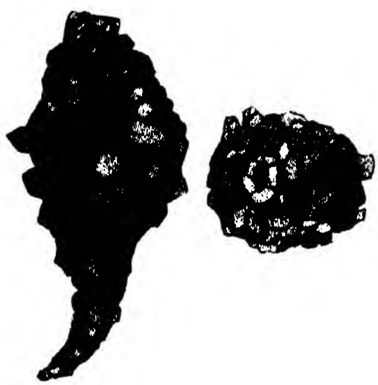
Text-fig. 4. *Proteonina difflugiformis* (H. B. BRADY). ×100.

Remarks. — This species was found in nearly every collection from the various stations in Mutsu Bay. CUSHMAN (1910) reported this species from the south-east coast of Japan, while I (1929) have found it also in the shallow waters of Hokkaido. Judging from the records previously published, it may be assumed that the present species is restricted to comparatively cold water and is fairly widely distributed. In the case of the specimens which were obtained at the stations situated between Ōshima and Bentenjima in Mutsu Bay, the test has a thin and somewhat translucent wall built up of mica scales and sand grains smoothly cemented, but in those from other stations in this bay the wall of the test is beset with shiny quartz grains.

5. **Proteonina crassa,** n. sp.
(Text-fig. 5)

Description. — Test elongate, fusiform, about twice as long as broad, usually somewhat curved, tapering into a long projection at the base, apertural end slightly drawn out; wall composed of comparatively large sand grain loosely cemented; aperture simple, rounded, terminal at the short tubular neck produced from the main body; color dark or blackish grey.

Length, 1.28–1.95 mm; diameter, 0.65–0.85 mm.



Text-fig. 5. *Proteonina crassa*, n. sp. ×25.
a, side view. b, apertural view.

Localities. — Off Yunoshima, 10–18 fathoms; between Ōshima and Bentenjima, 27–33 fathoms.

Remarks. — This species seems to be rather common at the localities above mentioned, but it is difficult to obtain complete specimens as they easily fall into pieces, the connection among the agglutinated materials of the test being very loose. In regard to the shape of the test the present species closely resembles *Proteonina helenae*. But the materials of the test are different in both species, viz. in the present species the test is composed of coarse sand grains, while in *Proteonina helenae* it is made up of fragments of the broken tests of the other Foraminifera.

Family **Reophacidae.**

Test consisting of either an irregular or a generally rectilinear series of chambers, typically increasing in size as added, simple or labyrinthic; wall chitinous with usually an exterior of agglutinated material, sand grains, sponge spicules, or the tests of other foraminifera; aperture usually terminal, simple or multiple.

Subfamily Reophacinae.

Chambers typically in a regular rectilinear series.

Genus REOPHAX Montfort, 1808

Test free, elongate, composed of several undivided chambers, ranging from overlapping to remotely separated ones connected by stolon-like necks, in a straight or curved linear series; wall single, of agglutinated material, firmly cemented, sand grains, mica scales, sponge spicules, or other foraminifera; aperture simple, terminal, sometimes with a slight neck.

6. Reophax scorpiurus Montfort.

(Text fig. 6)

Lituola scorpiurus, H. B Brady, 1864, p. 467, pl. 48, fig. 5; 1870, p. 291; Dawson, 1871, p. 86, fig. 4.

Lituola nautiloida, var. scorpiurus, Bütschli, 1880–1882, p. 192, pl. 5, fig. 18.

Reophax scorpiurus, H. B. Brady, 1881 (b), p. 11; 1884, p. 291, pl. 30, figs. 12, 15–17; Egger, 1893, p. 65, pl. 4, fig. 18, pl. 5, figs. 45, 46; Goës, 1894, p. 24, pl. 5, figs. 158, 159, pl. 6, figs. 164–167; Chapman, 1895, p. 14; Goës, 1896, p 26; Flint, 1897, p. 273, pl. 16, fig. 3; Millett, 1899, p. 254; Bagg, 1908, p. 126; Cushman, 1910, p. 83, text-figs. 114–116; Rhumbler, 1911, pl. 8, figs. 2–5; 1913, p, 470; Heron-Allen and Earland, 1913 (c), p. 43; Pearcey, 1914, p. 1006; Heron-Allen and Earland, 1916 (a), p. 222; Cushman, 1920 (a), p, 6, pl. 1, figs. 5–7; 1920 (b). p. 598; 1921. p. 65, pl. 6, fig. 6.

Nodulina scorpiura, Kiaer, 1900, p 23.

Text-fig. 6. *Reophax scorpiurus* Montfort. ×25.

Description. — Test free, composed of several somewhat inflated chambers increasing in size as added, usually curved in the early portion: wall consisting of comparatively coarse sand grains and of other foreign matters; aperture simple at the slightly produced end of the last-formed chamber; color varying with the

agglutinated material of the wall.

Length, up to 2.40 mm.

Localities. — The depth at the stations at which the material was obtained was 4–33 fathoms.

Remarks. — Various forms of irregular shape are included under this specific name. In Mutsu Bay this species is rather common, and the test is usually elongated, tapering and slightly curved. Ir general features the species looks like *Reophax dentaliniforms*, but the absence of a distinct cylindrical neck separates the present species from a fore said species.

7. Reophax pilulifer H. B. Brady.

(Text-fig. 7)

Reophax pilulifer, H. B. Brady, 1884, p. 292, pl. 30, figs. 18–20; Flint, 1897, p. 273, pl. 18, fig. 1.

Reophax pilulifer, Goës, 1894, p. 25, pl. 6, figs. 176–180; Chapman, 1895, p 15; Goës, 1896, p. 27; Cushman, 1910, p. 85, text-figs 117, 118; 1920 (a), p. 7, pl. 2, fig. 1; 1921, p. 66, pl 12, fig. 1.

Description. — Test usually curved and sometimes straight, composed of three to seven subglobular chambers, increasing rapidly in size as added; wall consisting of coarse sand grains, but presenting a rather smooth exterior; aperture simple, terminal at the end of the last-formed chamber; color grey or brown.

Text-fig. 7. *Reophax pilulifer* H. B. Brady. ×30.

Length, about 1.50 mm.

Localities. — Off Yunoshima, 15 fathoms; off Futagojima, 18–25 fathoms; near Oshima, 23 fathoms.

Remarks. — This species was hitherto obtained only from the deep sea. In the Challenger Report H. B. Brady (1884) recorded it from a depth of 1875 fathoms in the eastern sea of Japan, and Cushman (1910) reported this species at a depth of 437 fathoms off the southern coast of Japan. It seems rather peculiar that several specimens of this species have been found in such shallow waters as in Mutsu Bay.

8. **Reophax curtus** CUSHMAN.
(Text-fig. 8)

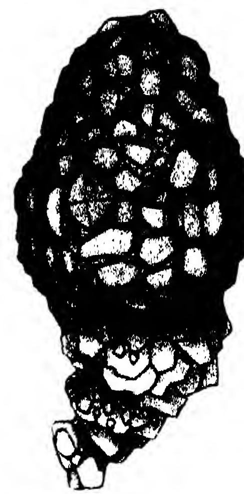
Reophax scarpiurus (part), GOËS, 1894, p. 24, pl 5, figs. 160–163.
Reophax curtus, CUSHMAN, 1920 (a), p. 8, pl. 2, figs. 2, 3.

Description. — Test somewhat fusiform, tapering, straight or often slightly curved in the early portion, composed of three or four chambers, each larger than its predecessor, last-formed chamber oval or fusiform, occupying a large proportion of the test; wall constructed of sand grains cemented neatly with a considerable amount of brown cementing material; aperture simple, terminal, situated at the produced end of the chamber without definite neck; color usually brown.

Length, up to 1.50 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 18–25 fathoms; near Ōshima 23 fathoms.

Remarks. — I have identified the specimens from Mutsu Bay as *Reophax curtus* as they show the features identical with those of this species except for the color of the test. The color of the test is brown in the case of the specimen from Mutsu Bay while it is grey in the specimens reported by CUSHMAN (1920). However, the color of the test usually varies in great deal with that of the cementing material, and thus is not to be taken as one of the characteristics which distinguish the arenaceous Foraminifera.



Text-fig. 8. ***Reophax curtus*** CUSHMAN. ×50.

9. **Reophax bilocularis** FLINT.
(Text-fig. 9)

Reophax bilocularis, FLINT, 1897, p. 273, pl. 17, fig 2; CUSHMAN, 1910, p. 90, text-fig. 127a, b; 1920 (a), p. 10, pl. 3, figs. 3, 4; 1921, p. 74, pl. 12, fig. 7.

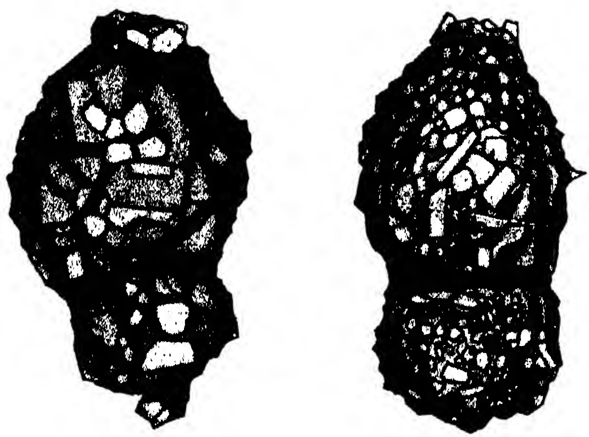
Description. — Test composed of two inflated chambers arranged in a straight or a curved line, initial end rounded or occasionally with a very small chamber, apertural end produced into a short

cylindrical neck; wall built up of rather coarse sand grains cemented firmly with yellowish grey cement; aperture simple, nearly circular at the end of a short tubular neck.

Length, up to 1.50 mm.

Localities. — It was obtained at nearly all stations, 8–30 fathoms.

Remarks. — This species is rather common in Mutsu Bay. As shown in figures, the specimens from this bay differ from those figured



Text-fig. 9. *Reophax bilocularis* FLINT. ×50.

by FLINT 1) in the rather short test composed of chambers not strongly elogated, 2) in the suture which is not strongly depressed, and 3) in the material of the wall consisting mainly of coarse sand grains and not being mixed with cast tests of other Foraminifera. I have identified the specimens from Mutsu Bay as *Reophax bilocularis* on the basis of the test consisting of two chambers.

10. Reophax excentricus CUSHMAN.

(Text-fig. 10)

Reophax excentricus, CUSHMAN, 1910, p. 92, text-fig 143; 1927 (a), p. 133, p. 1, fig. 3.

Description. — Test straight or slightly curved, composed of four to six inflated chambers increasing rapidly in size from the first as added; wall consisting of coarse sand grains cemented firmly together; aperture rounded, at the end of a short tubular neck, slightly produced

from the last-formed chamber; color varying with the agglutinated material of the test.

Length, up to 2.60 mm.

Localities. — It is obtained at the most of the stations, at depths of 8–30 fathoms.

Remarks. — The species seems to be common in Mutsu Bay. The type-specimen was obtained from the stomach of *Holothurians*, which was dredged by the U. S. Fish Commission Steamer "Albatross" in the Bering Sea from a depth of 1771 fathoms. The specimens from Mutsu Bay are rather larger than the type, but they resemble it very closely in general features.

Text-fig. 10 *Reophax excentricus* CUSHMAN. ×30.

11. Reophax dentaliniformis H. B. BRADY.

(Text-fig. 11)

Reophax dentaliniformis, H. B. BRADY, 1881 (a), p. 49; 1884, p. 293, pl. 30, figs. 21, 22; GOËS, 1894, p 25, pl. 6, figs. 172–175; SCHLUMBERGER, 1894, p. 239; CHAPMAN, 1895, p. 15; GOËS, 1896, p. 27; FLINT, 1897, p. 274, pl. 18, fig. 2; MILLETT, 1899, p. 254; CUSHMAN, 1908, p. 23; 1910, p. 87, text-fig. 121; RHUMBLER, 1911, pl. 8, figs. 21, 22; 1913, p. 473; PEARCEY, 1914, p. 1006; CUSHMAN, 1920 (a), p. 18, pl. 5, figs. 4, 5; 1921, p. 68, pl. 12, fig. 4; 1927 (a), p. 132.

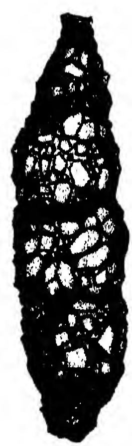
Nodulina dentaliniformis, KIAER, 1900, p. 24.

Description. — Test slender, cylindrical, tapering, straight or more or less curved, composed of rather coarse sand grains, but neatly cemented; aperture simple at the end of a short tubular neck; color usually grey.

Length, up to 1.80 mm.

Localities. — Near Futagojima, 18 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This species is comparatively



Text-fig. 11. *Reophax dentaliniformis* H. B. BRADY. ×40.

rare in Mutsu Bay. Its occurrence was also reported by SCHLUMBERGER (1894) from the Sea of Okhotsk.

12. **Reophax enormis** HADA.

(Text-fig. 12)

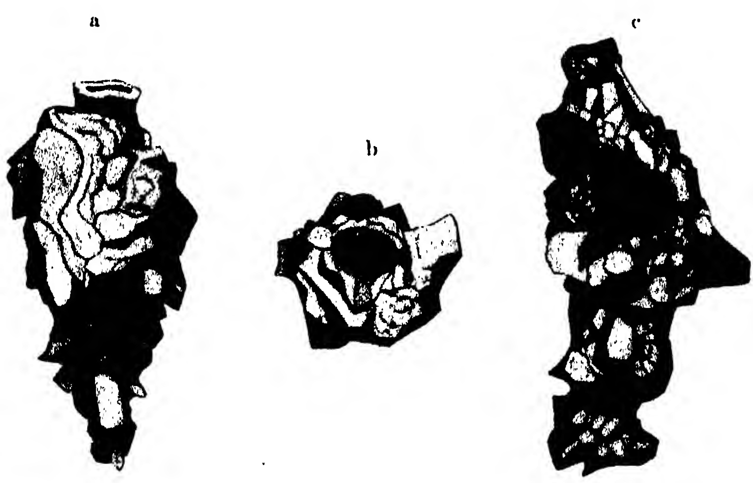
Reophax enormis, HADA, 1929, p. 10, text-figs. a–d.

Description. — Test typically tapering, composed usually of three chambers arranged in a nearly straight series, showing an irregular contour, apertural end drawn out into a short tubular neck; wall constructed of sharp edged sand grains giving an irregular appearance; sutures often indistinct due to incomplete septa; aperture simple, at the end of a short neck; color variable in accordance with that of material forming the wall.

Length, up to 0.95 mm.

Localities. — Off the Marine Biological Station, 10–18 fathoms; off Futagojima, 18–25 fathoms; near Ōshima, 23 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This species occurs not very abundantly, but is widely distributed in Mutsu Bay. I (1929) have also collected some specimens of it in the inlet of Oshoro, Hokkaido. The species is more or less



Text-fig. 12. *Reophax enormis* HADA. ×60.

a, side view of a specimen. b, apertural view of the same. c, side view of the other specimen.

similar to *Reophax scorpiurus* in general appearance, but it may be distinguished from the latter by the ill-defined sutures and by the surface which is very coarse.

13. **Reophax gracilis** (KIAER).

(Text-fig. 13)

Nodulina gracilis, KIAER, 1900, p. 24, text-figs. (without No.).

Description. — Test elongate, composed of about nineteen loosely connected chambers in an irregularly curved linear series, but separated by distinct sutures, tapering gradually to the initial end; wall finely arenaceous, thin and delicate; aperture rounded, terminal; color light or yellowish grey.

Length, about 0.55 mm.

Locality. — Off Yunoshima, 18 fathoms.

Remarks. — A few specimens of this species were found in my material obtained from the above station. They are closely similar to the Norwegian specimens figured by KIAER (1900), but on the whole they are smaller than the latter.

Text-fig. 13. *Reophax gracilis* (KIAER). ×120.

Family **Ammodiscidae.**

Test composed of a globular proloculum and long, undivided, tubular, second chamber, usually close coiled, at least in the young, planispiral, conical spiral, or irregularly winding; wall of fine arenaceous material with much cement, usually of a yellowish- or reddish-brown color; aperture formed by the open end of the tubular chamber.

Subfamily AMMODISCINAE.

Test free.

Genus GLOMOSPIRA RZEHAK, 1888.

Test free, consisting of a proloculum and long, tubular, second

chamber winding about its earlier coils in various planes; wall of fine arenaceous material with a large proportion of yellowish- or reddish-brown cement; aperture at the end of the tube.

14. Glomospira gordialis (JONES and PARKER).

(Text-fig. 14)

Trochammina gordialis. CARPENTER, PARKER and JONES, 1862, p. 141, pl. 11, fig. 4.
Ammodiscus gordialis, H. B. BRADY, 1881 (b), p. 12; 1884, p. 333, pl. 38, fig. 7–9; EGGER, 1893, p. 72, pl. 5, figs. 39, 40; FLINT, 1897, p. 279, pl. 24, fig. 1.
Gordiammina gordialis, KIAER, 1900, p. 21; RHUMBLER, 1904, p. 282, text-fig. 132; CUSHMAN, 1910, p. 76, text-figs. 88–90; PEARCEY, 1914, p. 1005; LACROIX, 1929, p. 21, text-fig. 31.
Glomospira gordialis, CUSHMAN, 1918, p. 99, pl. 36, figs. 7–9.

Description. — Test free, variable in shape, asymmetrical, composed of a proloculum and a long, tubular, undivided chamber of nearly uniform diameter coiled up in an irregular manner and in varying directions; wall arenaceous, neatly cemented with fine material; aperture simple, rounded, at the end of the tube; color reddish brown in the central coil, fading gradually into yellowish brown.

Text-fig. 14. *Glomospira gordialis*. (JONES and PARKER). ×110.

Diameter, about 0.38 mm.

Locality. — Near Futagojima, 18 fathoms.

Remarks. — This species seems to be rare; only two comparatively small specimens have been seen.

Family Lituolidae.

Test free, planispiral at least in the young, later portion in some genera uncoiled, divided into chambers, either simple or labyrinthic; wall arenaceous with varying proportions of cement in different genera and species, usually with a yellowish- or reddish-brown cement, the last-formed chamber in the adult often white; aperture simple or compound.

Subfamily HAPLOPHRAGMIINAE.

Test composed of simple chambers, not labyrinthic.

Genus HAPLOPHRAGMOIDES CUSHMAN, 1910.

Test of several coils, planispiral, usually not completely involute, chambers simple; wall single, arenaceous or with sponge spicules, firmly cemented, amount of cement varying greatly in different species; aperture simple, at the base of the apertural face of the chamber or in the face of the chamber.

15. Haplophragmoides emaciatum (H. B. BRADY).

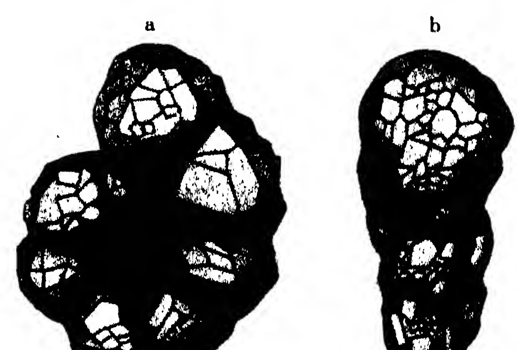
(Text-fig. 15)

Haplophragmium emaciatum, H. B. BRADY, 1884, p. 305, pl. 33, figs. 26–28; EGGER, 1893, p. 70, pl. 5, figs. 53, 54; CHAPMAN, 1895, p. 16; FLINT, 1897, p. 276, pl. 19, fig. 5.

Haplophragmium compressum, MILLETT, 1899, p. 359, pl. 5, fig. 8; HERON-ALLEN and EARLAND, 1915, p. 613, pl. 46, figs 20, 21.

Haplophragmoides emaciatum, CUSHMAN, 1910, p. 102, text-figs. 150–152; 1920 (a), p. 40, text-figs. 1–3, pl. 8, fig. 4; 1921, p. 80; HADA, 1929, p. 11.

Description. — Test nearly discoidal, planispiral, both faces concave, composed of two or more convolutions, of which the outer one consists of about seven inflated chambers, rapidly increasing in size; peripheral margin rounded; wall constructed of sand grains cemented neatly; sutures well marked externally; aperture slit-like, arched, at the base of the apertural face of the chamber; color brown in the larger individuals, greyish white in the smaller ones, dark color in the central portion of the test, fading gradually towards



Text-fig. 15. *Haplophragmoides emaciatum* (H. B. BRADY). ×65.
a, side view. b, apertural view.

the last-formed chamber.

Diameter, about 0.65 mm.

Localities. — Off Yunoshima, 10–18 fathoms; near Ōshima, 23 fathoms.

Remarks. — This species is rather rare in Mutsu Bay, and is represented by specimens of comparatively small size. Several specimens examined showed great diversity in color of the test and the material forming the wall. As already mentioned above, in larger specimens the test is brown in color and its wall is thick being composed of fine sand, while in smaller ones, it is greyish white in color and, moreover, is somewhat translucent, the wall being comparatively thin. In my previous paper (1929) I have reported on the occurrence of the present species in the waters of Hokkaido.

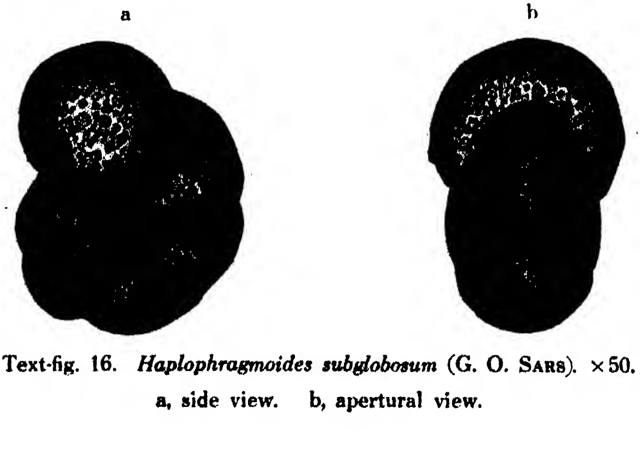
16. **Haplophragmoides subglobosum** (G. O. SARS).

(Text-fig. 16)

Haplophragmium subglobosum, H. B. BRADY, 1881 (b), p. 12.

Haplophragmium latidorsatum, H. B. BRADY, 1884, p. 307, pl. 34, figs. 7, 8, 10; GOËS, 1894, p. 21, pl. 5, figs. 102–123; CHAPMAN, 1895, p. 15; GOËS, 1896, p. 29; FLINT, 1897, p. 276, pl. 20, fig. 1; KIAER, 1900, p. 43; MILLETT, 1899, p. 360; HERON-ALLEN and EARLAND, 1911, p. 309; 1913 (c), p. 46, pl. 2, figs. 15, 16.

Haplophragmoides subglobosum, CUSHMAN, 1910, p. 105, text-figs. 162–164; PEARCEY, 1914, p. 1008; CUSHMAN, 1920 (a), p. 45, pl. 8, fig. 5; 1921, p. 81, pl. 15, fig. 1a, b.



Text-fig. 16. *Haplophragmoides subglobosum* (G. O. SARS). ×50.
a, side view. b, apertural view.

Description. — Test free, planispiral, depressed at the umbilical region, six to eight subglobular chambers forming the outer whorl; sutures marked with the deep depressions; wall thick, consisting of fine sand grains cemented neatly with a considerable amount of cementing material, giving a rather smooth appearance; aperture arched slit-like or irregularly formed at the base of the apertural face of the final chamber; color reddish brown or yellowish brown, often fading from the first visible chamber to the last-formed one.

Diameter, up to 0.80 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — A few specimens of small size occur in my collections obtained at the above localities. In each of these specimens the test is strongly depressed at the inner coil, but this feature was not noticed in the specimens hitherto described.

Genus AMMOBACULITES CUSHMAN, 1910.

Test free, the early chambers close coil, later ones uncoiling with typically a linear series of chambers, simple; wall arenaceous with a chitinous lining; aperture in the early stages at the base of the apertural face, in the adult circular and terminal.

17. Ammobaculites agglutinans (D'ORBIGNY).

(Text-fig. 17)

Haplophragmium agglutinans, H. B. BRADY, 1884, p. 301, pl. 32, figs. 19, 20, 24–26; EGGER, 1893, p. 68, pl. 4, figs. 16, 36; GOËS, 1894, p. 23, pl. 5, figs. 140, 141; CHAPMAN, 1895, p. 16; GOËS, 1896, p. 32; MILLETT, 1899, p. 357, pl. 5, fig. 1; BAGG, 1908, p. 126; HERON-ALLEN and EARLAND, 1909, p. 322; 1915, p. 612.

Ammobaculites agglutinans, CUSHMAN, 1910, p. 115, text-fig. 176; PEARCEY, 1914, p. 1010; CUSHMAN, 1920 (a), p. 60, pl. 12, fig. 3; 1920 (b), p. 600; 1921, p. 89, pl. 17, fig. 4.

Description. — Test elongate, planispiral and compressed in the early portion, consisting of one and more visible convolutions, the later portion in a linear series composed of cylindrical chambers; wall arenaceous with a considerable amount of cementing material; sutures indistinct in the early portion, but distinct in the later; aperture

Text-fig. 17. *Ammobaculites agglutinans* (D'ORBIGNY). ×80.

simple, terminal; color usually dark grey.

Length, about 0.55 mm.

Locality. — Off Yunoshima, 15 fathoms.

Remarks. — This species is widely distributed throughout temperate waters, and may be obtained from every depth. The species shows a great diversity in its size, color and texture. It seems highly probable that the specimens taken from deep water are greater in size than those obtained from shallow water close the coast. In Mutsu Bay the species is rather rare and is represented by specimens of comparatively small size.

18. Ammobaculites pseudospirale (WILLIAMSON).

(Text-fig. 18)

Proteonina pseudospiralis, WILLIAMSON, 1858, p. 2, pl 1, figs. 2, 3.
Haplophragmium pseudospirale, H. B. BRADY, 1884, p. 302, pl. 33, figs. 1-4; EGGER, 1893, p. 68, pl. 5, figs. 41, 42; GOËS, 1894, p. 23, pl. 5, figs. 146, 147; MILLETT, 1899, p. 358; KIAER, 1900, p. 44; SIDEBOTTOM, 1905, p. 3; RHUMBLER, 1911, pl. 2, fig. 15; 1913, p. 379; HERON-ALLEN and EARLAND, 1913 (c), p. 45; 1916 (a), p. 223, pl. 40, fig. 14.
Ammobaculites pseudospirale, CUSHMAN, 1920 (a), p. 62, pl. 12, fig. 4; 1921, p. 94, pl. 19, figs. 1, 2.

Text-fig. 18. *Ammobaculites pseudospirale* (WILLIAMSON). ×35.
a, side view.
b, apertural view.

Description. — Test thin, elongate, compressed, early portion showing a spiral growth, but later portion forming a nearly straight linear series; chambers separated by scarcely perceptible sutural lines; wall composed of coarse sand grains united together with much cementing material; aperture irregular, sometimes oblong or slit-like either at the end of the produced portion of the final chamber or at the end of a short neck; color reddish

brown in the commencement, gradually fading into light yellow towards the last-formed chamber.

Length, about 1.30 mm.

Localities. — Off Yunoshima. 18 fathoms; off Futagojima, 18–25 fathoms.

Remarks. — Judging from the records previously published the species seems to be distributed in comparatively shallow waters. In Mutsu Bay I have secured several specimens which are fairly variable in contour of the test.

19. Ammobaculites cassis (Parker).

(Text-fig. 19)

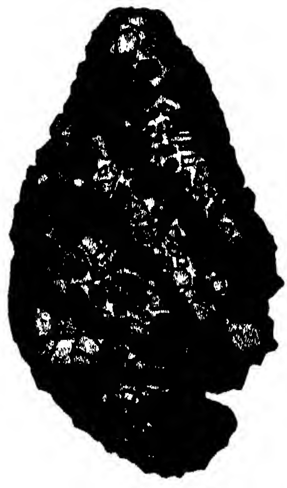
Haplophragmium cassis, H. B. Brady, 1884, p. 301, pl. 33, figs. 17–19; Egger, 1893, p. 69, pl 5, figs 55, 56; Goës, 1894, p. 24, pl. 5, figs 152–157; Flint, 1897, p 275, pl 19, fig. 4; Millett, 1899, p. 359, pl. 5, figs. 1–6.

Ammobaculites cassis, Cushman, 1920 (a), p 63, pl. 12, fig. 5; 1921, p. 91, pl. 14, fig. 4; Hada, 1929, p. 11.

Description. — Test elongate, arcuate, strongly compressed, outer margin rounded, but inner margin more or less acute; early chambers arranged spirally, later ones uncoiled but obliquely placed, somewhat inflated; wall composed of coarse sand grains with much cement, forming rather smooth surface; sutures comparatively obvious in the later uncoiled portion; aperture simple at the distal end; color grey or dark grey.

Length, up to 1.80 mm.

Localities. — Off Futagojima, 23 fathoms, near Ōshima, 23 fathoms.

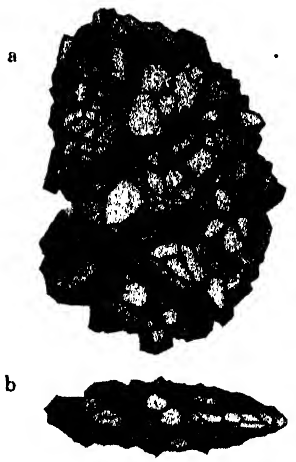


Text-fig. 19. *Ammobaculites cassis* (Parker) ×40.

Remarks. — From previous records it appears that the present species seems to have its home in the Arctic Ocean, and occurs in most cases in cold water. I (1929) have formerly obtained several specimens of this species from the port of Nemuro, Hokkaido.

20. Ammobaculites calcareum (H. B. BRADY).
(Text-fig. 20)

Haplophragmium calcareum, H. B. BRADY, 1884, p. 302, pl. 33, figs. 5-12.
Ammobaculites calcareum, CUSHMAN, 1921, p. 90, pl. 17, fig. 3.



Text-fig. 20. *Ammobaculites calcareum* (H. B. BRADY). ×40. a, side view. b, apertural view.

Description. — Test more or less elongate, compressed, at first exhibiting a single convolution consisting of three to five visible chambers, afterwards showing a nearly straight linear series; sutures rather distinct; wall composed of sand grains cemented with rich cement; aperture simple, terminal; color light grey, more deeply colored at the coiled portion.

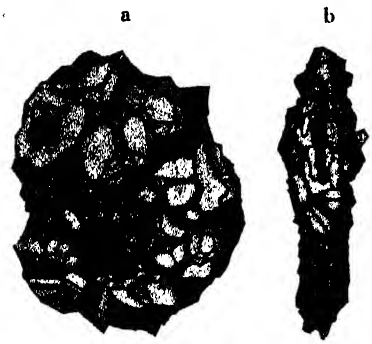
Length, 1.13 mm.

Locality. — Off Yunoshima, 18 fathoms.

Remarks. — This is exceedingly rare species in Mutsu Bay, so far as I investigated; a single specimen being found in the material taken from the bottom of the bay.

21. Ammobaculites americanus CUSHMAN.
(Text-fig. 21)

Haplophragmium fontinense, H. B. BRADY, 1884, p. 305, pl. 34, figs. 1-4; EGGER, 1893, p. 69, pl. 5, fig. 47; GOËS, 1896, p. 31.
Ammobaculites americanus, CUSHMAN, 1910, p. 117, text-figs. 184, 185; PEARCEY, 1914, p. 1010; CUSHMAN, 1920 (a), p. 64, pl. 12, figs. 6, 7.



Text-fig. 21. *Ammobaculites americanus* CUSHMAN. ×50. a, side view. b, apertural view.

Description. — Test planispiral, much compressed, composed of numerous flattened chambers, forming

three or four convolutions in the commencement and showing a tendency to form a straight linear series in the fully developed individuals; sutures not very distinct, slightly depressed; wall rather coarsely arenaceous, firmly cemented; aperture elongate, irregularly formed; color grey in the central coil, gradually fading towards the outer ones.

Length, about 0.75 mm.

Locality. — Off Yunoshima, 18 fathoms.

Remarks. — Only two specimens of this species have been secured from Mutsu Bay, and they are of small size, as compared with the specimens recorded by H. B. BRADY (1884) and CUSHMAN (1920) from the other seas.

Family **Textulariidae.**

Test in the earliest stages, at least in primitive forms, planispiral, later in all but the most accelerated forms developing a biserial stage, final development taking various forms, usually becoming uniserial in the more specialized types; wall arenaceous, with a varying proportion of cement in different genera and species; aperture typically at the inner margin of the last-formed chamber in the biserial forms, becoming terminal and sometimes multiple in the uniserial forms.

Subfamily TEXTULARIINAE.

Test typically biserial or becoming uniserial, usually free; chambers simple or labyrinthic; wall arenaceous, usually perforate; aperture simple or cribrate.

Genus TEXTULARIA DEFRANCE, 1824.

Test free, elongate, tapering, usually compressed with the zig-zag line between the chambers on the middle of the flattened sides, early chambers in the microspheric form usually planispirally coiled, later biserial, chambers simple, not labyrinthic; wall arenaceous, the relative amount of cement varying much; aperture, typically an arched slit at the inner margin of the chamber, occasionally in the apertural face.

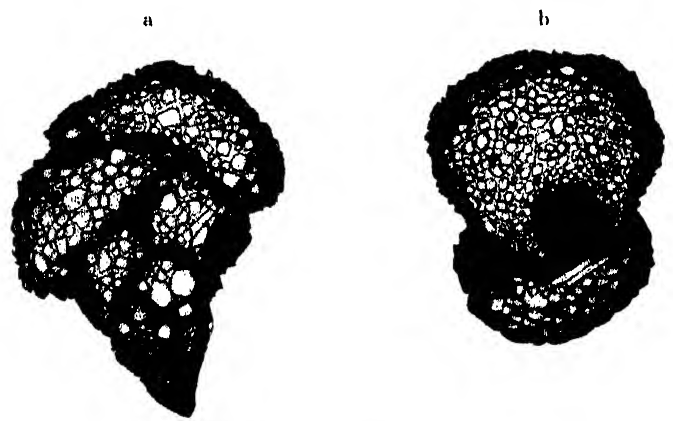
22. **Textularia candeiana** D'ORBIGNY.

(Text-fig. 22)

Textularia sagittula, var. *candeiana*, MILLETT, 1899, p. 562, pl. 7, fig. 2.

Textularia candeiana, CUSHMAN, 1911, p. 12, text-figs. 14–17; 1921, p. 109; 1922 (a), p. 8, pl. 1, figs. 1–3; 1922 (b), p. 23, pl. 2, fig. 2; 1922 (c), p. 50, pl. 11, figs. 7, 8; 1926 (a), p. 76.

Description. — Test somewhat pyramidal, tapering rather sharply to the initial end, marginal edges slightly curved, more or less acute in the commencement, but rounded distally; chambers numerous arranged biserially, increasing rapidly in size in the final portion which consists of highly inflated chambers; sutures marked deeply; texture



Text-fig. 22. *Textularia candeiana* D'ORBIGNY. ×50.
a, side view. b, apertural view.

neatly arenaceous, firmly cemented; aperture forming an arched sinus at the base of the inner margin of the last-formed chamber; color grey.

Length, about 0.85 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 18–25 fathoms.

Remarks. — In Mutsu Bay this species is not so common as other species of *Textularia*, and it is represented by specimens of rather small size.

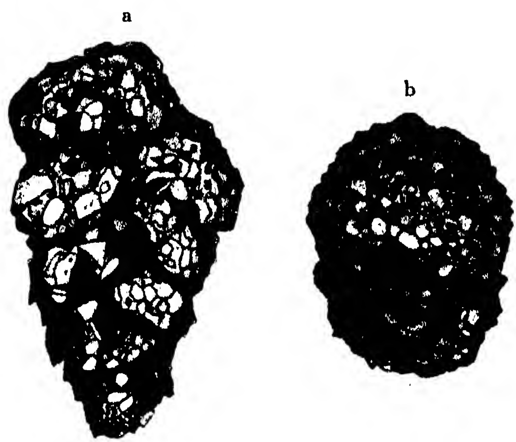
23. Textularia hauerii d'ORBIGNY.

(Text-fig. 23)

Textularia hauerii, HERON-ALLEN and EARLAND, 1915 p. 628, pl. 47, figs. 21-23; CUSHMAN, 1921, p. 105, pl. 19, fig. 6.

Description. — Test elongate, slightly compressed, apical end rounded, composed of about six chambers in each row of the biserial arrangement; chambers indistinct in the aboral portion, gradually becoming more inflated towards the oral portion, being separated by sutures, increasing rapidly in height as added; texture coarsely arenaceous, firmly united together with a considerable amount of cementing material; aperture irregular, nearly oblong; color grey.

Length, up to 1.60 mm.



Text-fig. 23. *Textularia hauerii* d'ORBIGNY. ×35.
a, side view. b, apertural view.

Localities. — Off Yunoshima, 10-18 fathoms; off Futagojima, 18-25 fathoms.

Remarks. — In the reports previously published by CUSHMAN (1921) this species was recorded from shallow water of tropical seas, whereas it seems to occur also in rather cold water as in Mutsu Bay.

24. Textularia cuneata, n. sp.

(Text-fig. 24)

Description. — Test compressed, elongate, two and one-half times as long as broad, slightly tapering, both ends blunt, peripheral margin irregular, rounded, apertural face truncate; chambers arranged biserially, usually six to eight forming each series, increasing in height towards the oral extremity; sutures distinct, set obliquely; wall com-

posed of coarse sand grains cemented firmly with grey cementing material; aperture rather large, nearly circular, and almost at the center of the apertural face; color varying with the agglutinated material of the wall.

Length, up to 1.85 mm; breadth, about 0.65 mm; thickness, about 0.36 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 18–25 fathoms; near Ōshima, 23 fathoms.

Remarks. — This new species is very common in Mutsu Bay, and represents one of the larger forms among arenaceous Foraminifera found in this bay. It shows a close resemblance to *Textularia luculenta* in the outline of the test and in the character of the aperture, but differs from the latter in texture of the wall and in number of the chambers.

a b

Text-fig. 24. *Textularia cuneata*, n. sp. ×40.
a, side view. b, peripheral view.

25. Textularia parvula CUSHMAN.

(Text-fig. 25)

Textularia parvula, CUSHMAN, 1922 (a), p. 11. pl. 6, figs. 1, 2.

Description. — Test small, much elongate, somewhat compressed, tapering towards the apical end, comoped of numerous chambers arranged biserially; sutures distinct; wall neatly delicate, arenaceous; aperture forming an arched opening at the base of the inner margin of the final chamber; color brown.

Length, up to 0.55 mm.

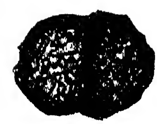
Localities. — Off Futagojima, 25 fathoms; near Ōshima, 23 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This small arenaceous form is commonly found in the

deeper area of Mutsu Bay. It is somewhat similar to *Textularia stricta* in the outline of the test, but differs remarkably from the latter in size of the test. It resembles *Textularia parvula* in its small size and in the general contour of the test, but seemingly varies from that species in the structure of the aperture. The aperture in our specimens is narrowly arched, while in CUSHMAN's (1922) figures it seems to form a more rounded opening.

a

b



Text-fig. 25. *Textularia parvula* CUSHMAN. ×120.
a, side view.
b, apertural view.

Genus BIGENERINA D'ORBIGNY, 1826.

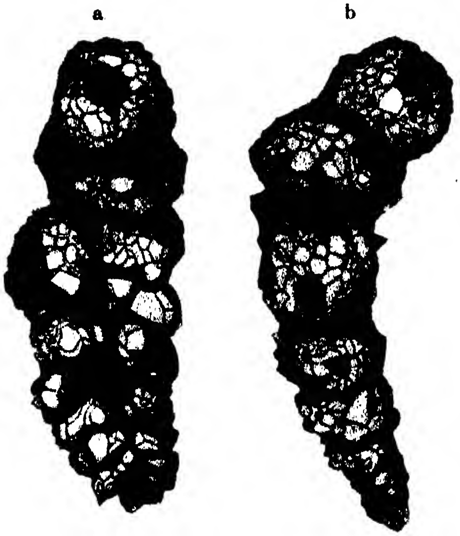
Test free, the early chambers biserial, later ones uniserial in a rectilinear series, not labyrinthic; wall usually thick, arenaceous, usually coarse but often smooth finished; aperture in the young biserial stage at the base of the inner margin of the chamber, in the adult uniserial stage terminal, rounded or oval simple.

26. Bigenerina nodosaria D'ORBIGNY.
(Text-fig. 26)

Textularia sagittula, forma *bigenerina*, GOËS, 1882, p. 78, pl. 5, figs 159–161.

Bigenerina nodosaria, H. B. BRADY, 1884, p. 369, pl. 44, figs. 14–18; GOËS, 1894, p. 37, pl. 7, figs. 313–323; 1896, p. 44; FLINT, 1897, p. 286. pl. 31, fig. 4; KIAER, 1900, p. 30; CUSHMAN, 1911, p. 27, text-figs. 46–48; 1920 (b), p. 603; 1921, p. 125, p. 26, fig. 2; 1922 (a), p. 24; 1922 (b), p. 25, pl. 2, figs. 5, 6; 1922 (c), p. 51.

Description.—Test elongate, at first compressed, composed of the biserially arranged chambers increasing progressively in breadth, then altered into the linear series consisting of cylindrical chambers narrower than the alternating portion; sutures distinct, slightly depressed in the biserial portion, but much more depressed in the uniserial; wall coarsely arenaceous with yellowish grey cement; aperture simple, rounded, at the center of the distal face of the last-formed chamber in the adult individuals; color grey.



Text-fig. 26. *Bigenerina nodosaria* D'ORBIGNY. ×40.
a, side view. b, peripheral view.

Length, about 1.45 mm.

Locality. — Off Futagojima, 23 fathoms.

Remarks. — The occurrence of this species in the waters surrounding Japan was first reported by H. B. BRADY (1884) in the Challenger Report, the specimens being obtained from Inland Sea. Only a single specimen was secured in Mutsu Bay at the station alluded to above.

Family **Verneuilinidae.**

Test, at least in the early stages, triserial, later biserial in some genera, and in most specialized ones becoming uniserial; wall arenaceous, the amount of cement varying in different genera and species; aperture simple or multiple.

Genus VERNEUILINA D'ORBIGNY, 1840.

Test usually free, sometimes attached, more or less elongate, tapering, transverse section rounded or triangular; chambers spirally arranged with three chambers marking a whorl, and the chambers arranged in three vertical columns; wall arenaceous; aperture, a low opening at the base of the inner margin of the chamber.

27. **Verneulina polystropha** (REUSS).
(Text-fig. 27)

Verneulina polystropha, H, B. BRADY, 1870, p. 301; 1878, p. 436, pl. 20, fig. 9a–c; 1881 (b), p. 13; 1884, p. 386, pl. 47, figs. 15–17; EGGER, 1893, p. 88, pl. 7, figs. 17, 18; KIAER, 1900, p. 32; SIDEBOTTOM, 1905, p. 10; CUSHMAN, 1908, p. 27; 1911, p. 53, text-fig. 85a, b; 1921, p. 139, pl. 32, fig. 1; HADA, 1929, p. 11.

Description. — Test elongate, conical, rounded at the oral end, pointed bluntly at the initial end, composed of the subglobular chambers in triserial arrangement; sutures marked with the deep depressions; texture rather coarsely arenaceous, cemented firmly with much cement; surface somewhat rough; aperture arched, distinct, at the base of the inner margin of the chamber; color reddish brown or yellowish white, usually fading distally.

Length, up to 0.62 mm.

Localities. — Widely distributed in Mutsu Bay.

Remarks. — This species is rather common in Mutsu Bay, and seems also to be common in the shallow waters off Hokkaido. It is variable not only in color, but also in the shape of the test.

Text-fig. 27. *Verneulina polystropha* (REUSS). ×75.
a, side view.
b, apertural view.

Family Miliolidae.

Test typically coiled about an elongate axis in various planes, at least in the microspheric young of even the specialized genera; chambers usually a half coil in length, simple in most genera, in a few with complex interiors, in the adult of many forms variously arranged; wall normally calcareous, imperforate, in some species of the more primitive genera with included sand grains on the exterior, under acid conditions developing a siliceous or chitinous test; aperture terminal, simple or cribrate, usually with a tooth.

Genus QUINQUELOCULINA D'ORBIGNY, 1826.

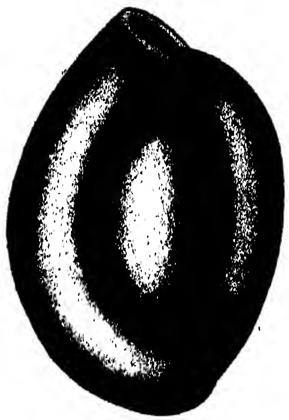
Test with the coiling in five planes, the chambers a half coil in length and added successively in planes 144° apart, five chambers completing a cycle, each chamber 72° from its adjacent one, but 144° from the immediately preceding one; wall imperforate, calcareous, often with arenaceous material on the exterior and in deep or brackish water occasionlly becoming siliceous; aperture usually with a simple tooth.

28. Quinqueloculina seminulum (LINNÉ).

(Text-fig. 28)

Miliolina seminulum, WILLIAMSON, 1858, p. 86, pl. 7, figs. 183–185; H. B. BRADY, 1881 (b), p. 9; 1884, p. 157, pl. 5, figs. 6a–c; EGGER, 1893, p. 40, pl. 2, figs. 38–40; GOËS, 1894, p. 18, figs. 838–838n, pl. 19, figs. 840–843; 1896, p. 81; FLINT, 1897, p. 297, pl. 43, fig. 2; SIDEBOTTOM, 1904, p. 10; CUSHMAN, 1908, p. 25, pl. 5, fig. 2; WIESNER, 1912, p. 231; HERON-ALLEN and EARLAND, 1915, p. 569, pl. 42, fig. 31.

Quinqueloculina seminulum, H. B. BRADY, 1870, p. 285; KIAER, 1900, p. 27; CUSHMAN, 1917 (a), p. 44, text-fig. 29, pl. 11, fig. 2; 1921, p. 416, text-figs. 19, 20, pl. 88, fig. 4a–c; 1929 (a), p. 24, pl. 2, figs. 1, 2; 1929 (b), p. 59; HADA, 1929, p. 14.



Text-fig. 28. *Quinqueloculina seminulum* (LINNÉ). ×50.

Description. — Test more or less longer than broad, peripheral margin rounded; chambers elongate, inflated; sutures distinct; surface smooth; aperture usually circular with a single tooth.

Length, about 1.00 mm.

Localities. — Near the Marine Biological Station, 5–10 fathoms; off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — This species occurs frequently in Mutsu Bay. CUSHMAN (1917) reported it from numerous stations in the adjacent sea of Japan, and I (1929) have also collected it from the coast of Hokkaido. ***Quinqueloculina seminulum*** is the name that has been universally adopted by many well-known authors for the quinqueloculine forms having smooth but rather variably shaped test.

29. Quinqueloculina vulgaris D'ORBIGNY.

(Text-fig. 29)

Quinqueloculina vulgaris, SCHLUMBERGER, 1893, p. 207, text-figs. 13, 14, pl. 2, figs. 65, 66; CUSHMAN, 1917 (a), p. 46, pl. 11, fig. 3; 1921, p. 417, text-fig. 21a, b, pl. 87, fig. 1a–c; 1925 (a), p. 138; 1929 (a), p. 25, pl. 2, fig. 3a–c; CUSHMAN and WICKENDEN, 1929, p. 2, pl. 1, fig. 7a–c; HADA, 1929, p. 15.

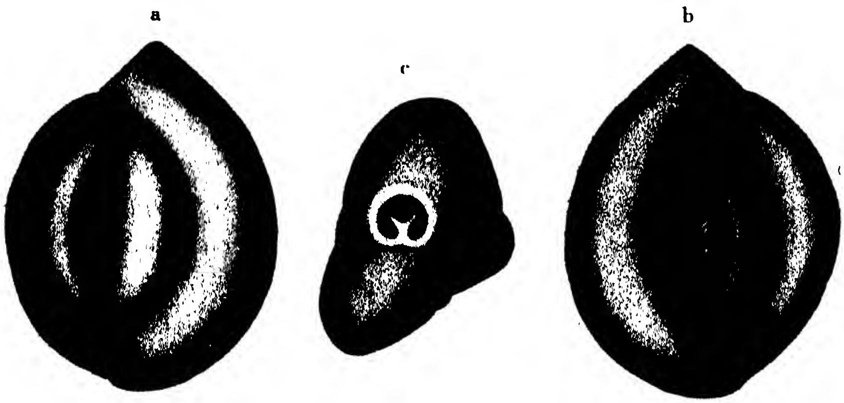
Miliolina vulgaris, SIDEBOTTOM, 1904, p. 11; HERON-ALLEN and EARLAND, 1913 (c), p. 28; 1915, p. 569; 1916 (a), p. 212.

Description. — Test nearly circular in front view, as long as broad, triangular in transverse section, periphery rounded; sutures distinct, depressed; surface smooth; aperture oval with a tooth bifid at the tip.

Length, about 0.65 mm.

Locality. — Off Yunoshima, 15 fathoms.

Remarks. — It is one of the rare species in Mutsu Bay, but it seems to be widely distributed in the neighbouring sea of Japan



Text-fig. 29. *Quinqueloculina vulgaris* D'ORBIGNY. ×70.
a, b, side view. c, apertural view.

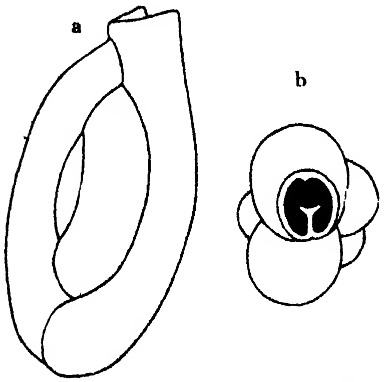
judging from CUSHMAN's records and from my examination (1929) of the species collected from shallow waters off Hokkaido. The species has a close resemblance to *Quinqueloculina seminulum* in the general contour of the test. However, it is not difficult to distinguish them by the ratio between length and breadth of the test. In this species the test is nearly as long as broad, while in *Q. seminulum* it is longer than broad.

30. Quinqueloculina pygmaea REUSS.

(Text-fig. 30)

Miliolina pygmaea, H. B. BRADY, 1884, p. 163, pl. 113, fig. 16a, b; EGGER, 1893, p. 38, pl. 2, figs. 23–25; SIDEBOTTOM, 1904, p. 13, pl. 4, figs. 4–6.
Quinqueloculina pygmaea, CUSHMAN, 1917 (a), p. 54; 1929 (a), p. 35.

Description — Test elongate, twice or more as long as broad, peripheral margin rounded; chambers long, curved, cylindrical, five chambers visible from the exterior; sutures distinctly marked; surface more or less rough; aperture oval, usually with a single bifid tooth, sometimes provided with a small additional upper tooth.



Text-fig. 30. *Quinqueloculina pygmaea* REUSS.
a, side view. b, apertural view.

Length, about 1.00 mm.

Localities. — Near the Marine Biological Station, 5–10 fathoms; off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms.

Remarks. — Numerous specimens of this species have been detected in the material from the above localities of Mutsu Bay. From the Japanese waters H. B. BRADY (1884) reported this species from south of Japan.

31. Quinqueloculina subquadra, n. sp.

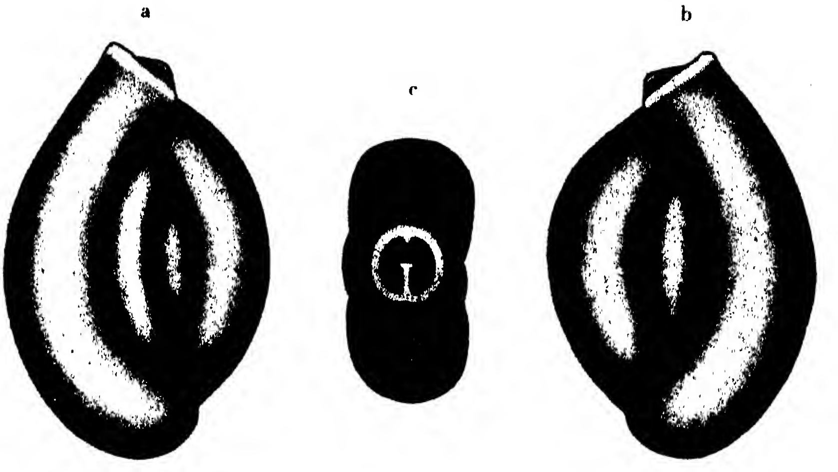
(Text-fig. 31)

Description. — Test elongate, compressed, about one and one-half times as long as broad, neither side strongly inflated, peripheral margin broadly rounded; chamber long, curved, five chambers externally visible; sutures slightly depressed; surface smooth; aperture nearly circular, usually provided with two teeth, the upper one short and pointed, the lower one bifid at the tip.

Length of the figured specimen, 1.10 mm; breadth, 0.71 mm; thickness, 0.34 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — This new species is commonly obtainable from comparatively shallow water in Mutsu Bay. In side view this species is similar to *Quinqueloculina seminulum*, but differs from the latter in having two teeth and in the nearly parallel sides in apertural view.



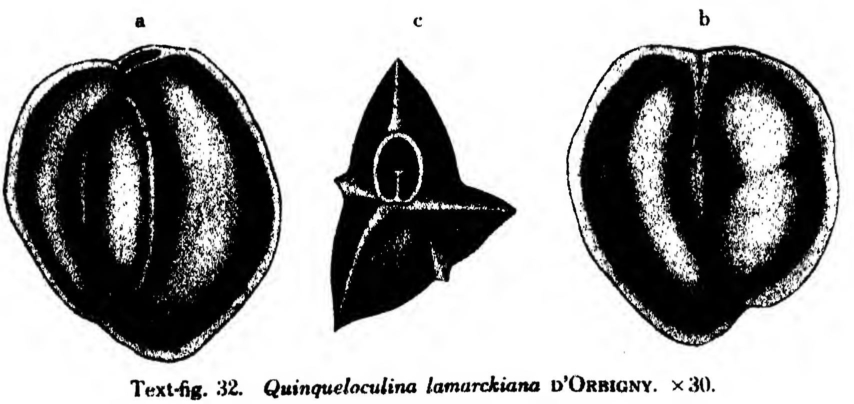
Text-fig. 31. *Quinqueloculina subquadra*, n. sp. ×50.
a, b, side view. c, apertural view.

32. Quinqueloculina lamarckiana D'ORBIGNY.

(Text-fig. 32)

Miliolina cuvieriana, H. B. BRADY, 1884, p. 162, pl. 5, fig. 12a–c; FLINT, 1897, p. 298, pl. 43, fig. 4.

Quinqueloculina lamarckiana, CUSHMAN, 1921, p. 418, text-figs. 22, 23, pl. 87, figs. 2, 3a–c; 1922 (b), p. 64; 1922 (c), p. 65, text-fig. 5, pl. 15, figs. 14, 15; 1924 (b), p. 63; 1925 (a), p. 139; 1926 (a), p. 81; 1929 (a), p. 26, pl. 2, fig. 6a–c.



Text-fig. 32. *Quinqueloculina lamarckiana* D'ORBIGNY. ×30.
a, b, side view. c, apertural view.

Description. — Test oval in side view, a little longer than broad, as nearly triangular seen from the apertural side; five chambers externally visible, of which three are large, forming respectively the curved triangular prisms with a sharp carinate edge, the other two small, forming sharp angular ridges; sutures distinct; surface smooth, polished; aperture oval with a T-shaped tooth, situated at the terminal end of the last-formed chamber, with or without the neck and the lip.

Length, up to 1.95 mm.

Localities. — Off Futagojima, 17–25 fathoms; near Oshima, 23 fathoms.

Remarks. — This species may be commonly found at the stations located off Futagojima, and in the specimens secured there are of comparatively large size. FLINT (1897) recorded this species from the Gulf of Tokyo.

33. Quinqueloculina curta CUSHMAN.

(Text-fig. 33)

Quinqueloculina disparilis, var. curta, CUSHMAN, 1917 (a), p. 49, text-figs. 30, pl. 14, fig. 2.

Quinqueloculina curta, CUSHMAN, 1921, p. 426, pl. 100, figs. 1, 2; HADA, 1929, p. 15.

Description. — Test nearly circular in side view, as long as broad or a little longer than broad, somewhat triangular in apertural view; chambers polygonal in apertural view, their outer surface rounded and marked with several longitudinal prominent costae, five chambers

Text-fig. 33. *Quinqueloculina curta* CUSHMAN. ×30.

a, b, side view. c, apertural view.

visible from the exterior; sutures distinct; wall generally smooth; aperture oval with a single tooth, surrounded with a thickened lip, and situated at the apertural end of the final chamber.

Length, about 1.35 mm.

Localities. — Near the Marine Biological Station, 5–10 fathoms; off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms.

Remarks. — This species is rather common in Mutsu Bay and is represented often by comparatively large specimens (1.35 mm.), but they are smaller than those (2.00 mm.) reported by CUSHMAN (1917) from Albatross station D. 4900, in 139 fathoms, off the coast of Japan. The specimens (1.10 mm.) which were formerly obtained by myself (1929) from off the coast of Hokkaido are smaller than those dealt with in the present paper.

Genus MASSILINA SCHLUMBERGER, 1893.

Test with the early chambers quinqueloculine, later ones added on opposite sides in a single plane, the quinqueloculine stage present in both megalospheric and microspheric forms; aperture simple, with a bifid tooth.

34. Massilina secans (D'ORBIGNY).

(Text-fig. 34)

Miliolina seminulum*, var. *disciformis, WILLIAMSON, 1858, p. 86, pl. 7, figs. 188. 189.

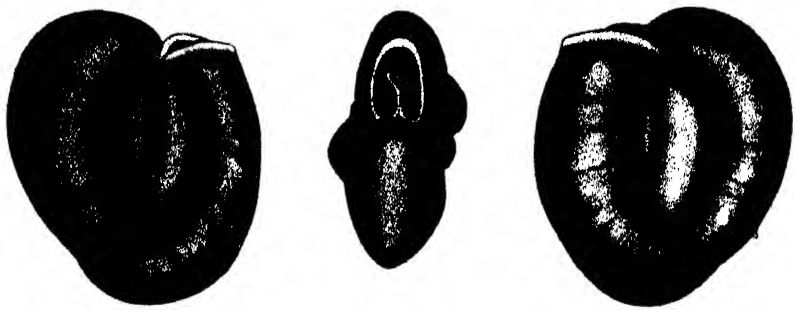
Quinqueloculina secans, H. B. BRADY, 1870, p. 288; KIAER, 1900, p. 28.

Miliolina secans, H. B. BRADY, 1884, p. 167, pl. 6, figs. 1, 2; EGGER, 1893, p. 45, pl. 2, figs. 59, 60; GOËS, 1894, p. 112, pl. 20, figs. 856–856g.

Massilina secans, CHLUMBERGER, 1893, p. 218, text-figs. 31–34, pl. 4, figs. 82, 83; MILLETT, 1898, p. 608, pl. 13, fig. 3; SIDEBOTTOM, 1904, p. 18; HERON-ALLEN and EARLAND, 1909, p. 317; 1913 (c), p. 34; 1915, p. 582, pl. 44, figs. 24–27; 1916 (a), p. 215; CUSHMAN, 1917 (a), p. 57; 1929 (a), p. 37, pl. 7, figs. 3, 4; HADA, 1929, p. 15.

Description. — Test nearly discoidal, compressed, peripheral margin subacute; earlier chambers smooth, ovoidal, arranged in a quinqueloculine manner, followed distally by transversely policated, compressed chambers in a single plane; aperture elongate, oval, with a single tooth bifid at the end, situated at the terminal end of the last-formed chamber.

a c b



Text-fig. 34. *Massilina secans* (D'ORBIGNY). ×30.
a, b, side view. c, apertural view.

Diameter, up to 1.25 mm.

Localities. — Between Asamushi and Yunoshima, 4 fathoms; near Gomejima, 7 fathoms.

Remarks. — I have obtained a single adult specimen from the sea-weed attached to the rock near Hadakajima in front of the Marine Biological Station, but the smaller young forms are frequently found in the material from a depth less than ten fathoms in Mutsu Bay. Formerly I have secured young specimens of this species in the inlet of Oshoro, Hokkaido (1929).

Genus SPIROLOCULINA D'ORBIGNY, 1826.

Test with the early chambers in the microspheric form quinqueloculine, later ones in a single plane, chambers a half coil in length; apertural end usually with a neck and lip, simple, with a simple or bifid tooth.

35. Spiroloculina depressa D'ORBIGNY.

(Text-fig. 35)

Spiroloculina depressa, WILLIAMSON, 1858, p. 82, pl. 7, fig. 117; H. B. BRADY, 1870, p. 285; WIESNER, 1912, p. 210; CUSHMAN, 1917 (a), p. 29, pl. 3, figs. 6–10; 1921. p. 394, pl. 81, fig. 2, pl. 100. figs. 4, 5; 1929 (a), p. 44, pl. 9, figs. 8, 9.

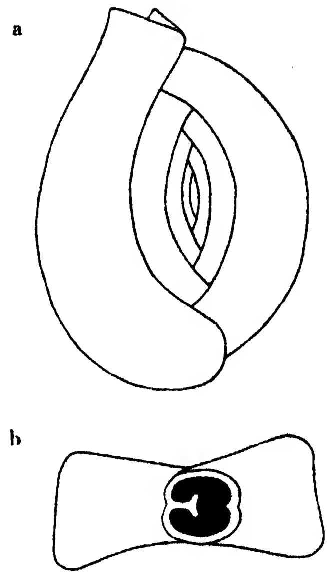
Spiroloculina limbata, H. B. BRADY, 1884, p. 150, pl. 9, figs. 15–17.

Description. — Test more or less elongate, both faces concave,

elliptical in side view, elongated and somewhat rectangular in end view; peripheral margin flattened; chambers long, curved, arranged in a single plane; terminal end of the last-formed chamber often slightly drawn out into a short neck with a thickened lip; aperture nearly circular, or oval, with a single bifid tooth, or two teeth: the upper one small and angular, the lower one bifid at the tip.

Length, up to 1.25 mm.

Localities. — Near the Marine Biological Station, 5–10 fathoms; off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.



Text-fig. 35. *Spiroloculina depressa* D'ORBIGNY. ×50. a, side view. b, apertural view.

Remarks. — This is a comparatively common species in Mutsu Bay. CUSHMAN (1917) reported this species from the following stations distributed among the waters surrounding Japan: 44 fathoms off Hokkaido; 66 fathoms in the eastern channel of Korea Strait; 139 fathoms in the eastern sea of Japan and 77 fathoms in Suruga Gulf.

36. Spiroloculina cushmani, n. sp.

(Text-fig. 36)

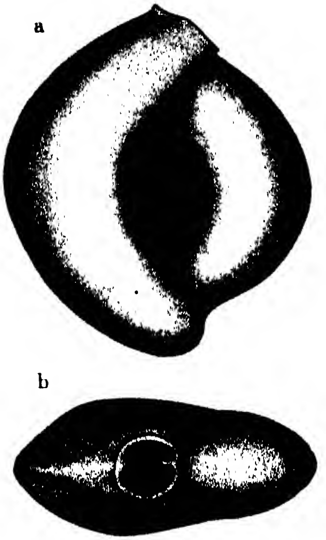
Description. — Test biconcave, nearly circular or oval in side view, typically a little longer than broad, peripheral margin rounded; several chambers visible, arranged in one plane, outer two chambers occupying comparatively the larger portion of the test; wall smooth without any ornamentation; apertural end not drawn out, but with a lip; aperture more or less circular, with two teeth: upper one in form of a short wedge, lower one bifid at the tip.

Length, 1.00–1.57 mm; breadth, 0.87–1.21 mm; thickness, 0.36–0.50 mm.

Localities. — Near the Marine Biological Station, 3–10 fathoms;

a

b



Text-fig. 36. *Spiroloculina cushmani*, n. sp. ×30.
a, side view. b, apertural view.

a

b

Text-fig. 37. *Spiroloculina costata*, n. sp. ×50.
a, side view. b, apertural view.

off Yunoshima, 10–18 fathoms.

Remarks. — In the collections from Mutsu Bay I have examined several specimens of this species more or less varying in shape, and these generally occur in the shallow water of this bay. It is similar to *Spiroloculina planissima* figured by CUSHMAN (1921, pl. 80, fig. 5a) in side view, but differs from that in the thicker test and in the rounded periphery.

37. **Spiroloculina costata**, n. sp.

(Text-fig. 37)

Description. — Test elongate, compressed, both faces concave, elliptical in side view; peripheral margin rounded; chambers nearly circular in transverse section; surface ornamented with numerous costae running longitudinally or irregularly; apertural end usually produced into a short neck with a slightly expanded lip; aperture circular with a simple tooth, usually bifid at the tip.

Length, about 1.15 mm; breadth, about 0.75 mm; thickness, about 0.20 mm.

Localities. — Near the Marine Biological Station, 3–10 fathoms; off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — In Mutsu Bay the new species occurs rather frequently. The breadth of the test is fairly variable with the individuals and sometimes

broader than that of the figured specimen. The characteristic feature of the costae on the test makes it distinguishable from the other species, and it differs from *Spiroloculina antilarum* in the broader test and in the irregular costae on the surface.

Genus TRILOCULINA D'ORBIGNY, 1826.

Test with the early chambers quinqueloculine, at least in the microspheric form, later ones added in planes 120° from one another, the third of each series added in the plane of the third preceding and covering it so that the surface of the test is composed of but three visible chambers, interior not labyrinthic; aperture simple, typically with a bifid tooth.

38. Triloculina trigonula (LAMARCK).
(Text-fig. 38)

Miliolina trigonula, WILLIAMSON, 1858, p. 84, pl. 7, figs. 180–182; H. B. BRADY, 1884, p. 164, pl. 3, figs. 14–16; EGGER, 1893, p. 41, pl. 2, figs. 64–66; GOËS, 1894, p. 115, pl. 22, fig. 870; CHAPMAN, 1895, p. 9; FLINT, 1897, p. 298, pl. 44, fig. 3; WIESNER, 1912, p. 227; HERON-ALLEN and EARLAND, 1915, p. 561; 1924, p. 405; IKARI, 1927, p. 10, pl. 1, figs. 2a–c.

Triloculina trigonula, H. B. BRADY, 1870, p. 285; KIAER, 1900, p. 27; CUSHMAN 1917 (a), p. 65, text-fig. 31, pl. 25, fig. 3; 1920 (b), p. 638; 1921, p. 452; 1922 (b), p. 72; 1922 (c), p. 69; 1926 (a), p. 82; 1929 (a), p. 56, pl. 12, figs. 10, 11, pl. 13, figs. 1, 2; HADA, 1929, p. 15.

Description. — Test nearly circular or ovate in front view, triangular

Text-fig. 38. *Triloculina trigonula* (LAMARCK). ×40.
a, front view. b, apertural view.

with rounded angles in apertural view; in full developed individuals three chambers visible from the exterior, somewhat inflated; sutures distinct; surface smooth; aperture transversely elliptical with a Y-shaped tooth.

Diameter, up to 1.20 mm.

Localities. — Near the Marine Biological Station, 5-10 fathoms; off Yunoshima, 10-18 fathoms; near Ōshima, 23 fathoms.

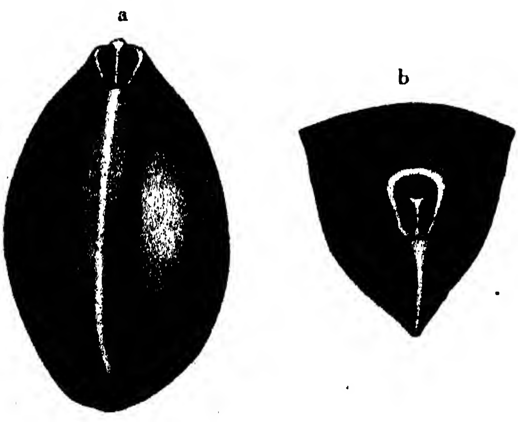
Remarks. — This species is frequently secured in the bottom-sand from Mutsu Bay. CUSHMAN (1917) recorded it from two Albatross stations off Japan and from one station in Suruga Gulf. IKARI (1927) reported this form also from the vicinity of the Misaki Marine Biological Station, and I have examined some specimens from the coast of Hokkaido.

39. Triloculina tricarinata D'ORBIGNY.

(Text-fig. 39)

Triloculina tricarinata, H. B. BRADY, 1864, p. 446, pl. 48, fig. 3; KIAER, 1900, p. 27; CUSHMAN, 1917 (a), p. 66, text-fig. 32, pl. 25, figs. 1, 2; 1920 (b), p. 638; 1921, p. 454, text-figs. 35, 36; 1922 (b), p. 72; 1927 (a), p. 139; 1929 (a), p. 56, pl. 13, fig. 3a–c.

Miliolina tricarinata, H. B. BRADY, 1881 (b), p. 9; 1884, p. 165, pl. 3, fig. 17a, b; EGGER, 1893, p. 42, figs. 35–37; GOËS, 1894, p. 114, pl. 21, figs. 866–869; 1896, p. 83; FLINT, 1897, p. 298, pl. 44, fig. 4; WIESNER, 1912, p. 228; HERON-ALLEN and EARLAND, 1924, p. 605; IKARI, 1927, p. 10, pl. 1, fig. 1a, b.



Text-fig. 39. *Triloculina tricarinata* D'ORBIGNY. ×50.
a, front view. b, apertural view.

Description. — Test in an adult somewhat elongate, triangular in apertural view, composed of three visible chambers; three angles sharply produced, keeled; surface smooth; aperture oval with a bifid tooth.

Length, up to 1.10 mm.

Localities. — Near the Marine Biological Station, 4–10 fathoms; off Yunoshima, 10–18 fathoms.

Remarks. — It is a rather rare species in Mutsu Bay. CUSHMAN (1917) reported it from a number of stations off Japan, and IKARI (1927) recorded it from bottom-sand taken at Misaki.

40. Triloculina circularis BORNEMANN.

(Text-fig. 40)

Miliolina circularis, H. B. BRADY, 1884, p. 169 pl. 4, fig. 3a–c, pl. 5, figs. 13. 14; EGGER, 1893, p. 43, pl. 2. figs. 61–63; CHAPMAN, 1895, p. 9; GOËS, 1896, p. 82; FLINT, 1897, p. 298, pl. 44, fig. 1; SIDEBOTTOM, 1904, p. 8; CUSHMAN, 1908, p. 26, pl. 5, figs. 5. 6, 10; HERON-ALLEN and EARLAND, 1909, p. 313; WIESNER, 1912, p. 230; HERON-ALLEN and EARLAND, 1913 (c), p. 26; PEARCEY, 1914, p. 995; HERON-ALLEN and EARLAND, 1915, p. 557; 1916 (a), p. 209; 1924, p. 604.

Triloculina circularis, CUSHMAN, 1917 (a), p. 67, text-figs. 33. 34, pl. 25, fig. 4, pl. 26, fig. 1; 1920 (b), p. 638; 1921, p. 462, pl. 92, figs. 1, 2; 1922 (b), p. 73; 1922 (c), p. 69; 1924 (b), p. 69, pl. 25, figs. 5, 6; 1925 (a), p. 141; 1926 (a), p. 82; 1929 (a), p. 58, pl. 13, figs. 6, 7, pl. 14, figs. 1, 2.

Description. — Test usually globular, nearly circular in side view, slightly compressed; three chambers externally visible in an adult; wall smooth, sometimes polished in a small young specimen; aperture oval with a short bifid tooth.

Diameter, up to 1.70 mm.

Remarks. — This species is abundant in the bay. CUSHMAN (1917) has recorded this species from numerous stations distributed among the seas adjacent to Japan and from comparatively shallow water.

Text-fig. 40. *Triloculina circularis* BORNEMANN. × 30.
a, b, side view. c, apertural view.

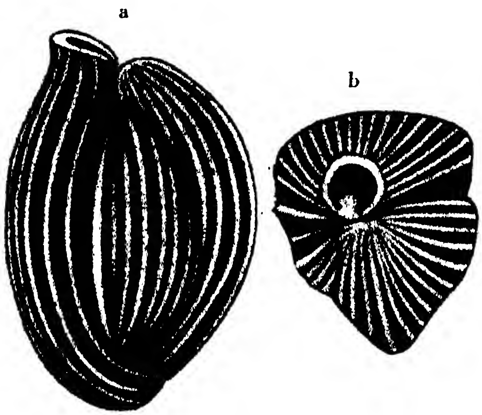
41. **Triloculina terquemiana** (H. B. BRADY).

(Text-fig. 41)

Miliolina terquemiana, H. B. BRADY, 1884, p. 166, pl. 114, fig. 1a, b; HERON-ALLEN and EARLAND, 1915, p. 563, pl. 41, figs. 29–31.

Triloculina terquemiana, CUSHMAN, 1917 (a), p. 72, pl. 27, fig. 2; 1921, p. 458; HADA, 1929, p. 15.

Description. — Test more or less elongate, composed of three visible chambers, triangular in apertural view, angles somewhat acute; surface ornamented with numerous longitudinal costae; aperture oval with a single rounded tooth.



Text-fig. 41. *Triloculina terquemina* (H. B. BRADY). ×80.
a, side view. b, apertural view.

Length, 0.40–0.80 mm.

Localities. — Near the Marine Biological Station, 7 fathoms; off Yunoshima, 15 fathoms.

Remarks.—The species is comparatively rare in Mutsu Bay. Of this species there are only a few recorded and these deal with the specimens obtained chiefly from shallow, warm water of the tropical sea. However, I have obtained specimens of this species also from shallow but rather cold water of Hokkaido (1929).

Family **Ophthalmidiidae.**

Test calcâreous, imperforate; early chambers at least planispiral, except in degenerate forms; wall without an arenaceous coating; aperture typically open, without a tooth.

Subfamily CORNUSPIRINAE.

Test made up of a proloculum and an elongate, planispiral, tubular second chamber.

Genus CORNUSPIRA SCHULTZE, 1854.

Test consisting of proloculum followed by a long, planispirally coiled, second chamber, rounded or complanate; wall calcareous, imperforate; aperture formed by the open end of the chamber, sometimes constricted and with a thickened lip.

42. Cornuspira involvens (REUSS).

(Text-fig. 42)

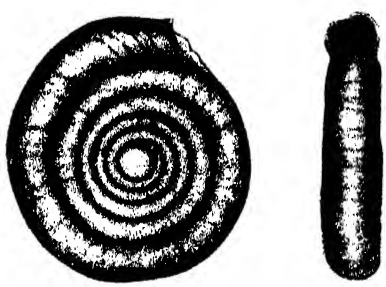
Cornuspira involvens, H. B. BRADY, 1881 (b), p. 8; 1884, p. 200, pl. 11, figs. 1-3; EGGER, 1893, p. 54. pl. 3, figs. 18, 19; FLINT, 1897, p. 303, pl. 48, fig. 3; MILLETT, 1898. p. 612; KIAER, 1900, p. 22; RHUMBLER, 1904, p. 285, text-fig. 137; 1907, p. 30, pl. 2, fig. 6; BAGG, 1908, p. 123; HERON-ALLEN and EARLAND, 1909 p. 318; RHUMBLER, 1911, pl. 5, fig. 4; 1913, p. 425; HERON-ALLEN and EARLAND, 1913 (c), p. 36; PEARCEY, 1914, p. 996; HERON-ALLEN and EARLAND, 1915, p. 593; 1916 (a), p. 217; CUSHMAN, 1917 (a), p. 25, pl. 1, fig. 2, pl. 2, fig. 2; 1920 (b), p. 634; 1921, p. 389, pl. 77, figs. 3, 4; 1922 (b), p. 58; 1922 (c), p. 62; 1924 (b), p. 51, pl. 18, figs. 1, 2; HERON-ALLEN and EARLAND, 1924, p. 610; CUSHMAN, 1925 (b), p. 44; 1926 (a), p. 80; 1929 (a), p. 80, pl. 20, figs. 6, 8; CUSHMAN and WICKENDEN, 1929, p. 4, pl. 2, fig. 3; HADA, 1929, p. 14.

Description.—Test formed of a proloculum and a planispirally coiled chamber, circular in side view, concave in both sides; wall rather thin, sometimes more or less translucent, showing numerous fine lines of growth; aperture at end of the coiled second chamber.

Diameter, about 0.30 mm.

Localities.—Near the Marine Biological Station, 5-10 fathoms; off Futagojima, 23 fathoms.

a b



Text-fig. 42. *Cornuspira involvens* (REUSS). ×120.
a, side view. b, peripheral view.

Remarks.—Of this species several specimens of small size (0.30 mm.) and with somewhat translucent test have been detected in the material from Mutsu Bay. CUSHMAN (1917) examined large specimens (1.00 mm.) of this species in the Albatross collections obtained from off the

coast of Japan. The specimens formerly reported by myself from the coast of Hokkaido were smaller than those recorded by CUSHMAN, and were as large as those obtained from Mutsu Bay this time.

Family **Trochamminidae.**

Test in general trochoid, of numerous chambers, or irregular; wall arenaceous, with much cement, usually of yellowish- or reddish-brown color.

Subfamily TROCHAMMININAE.

Test trochoid, chambers in spiral whorls; aperture ventral.

Genus TROCHAMMINA PARKER and JONES, 1860.

Test free or adherent, spiral, trochoid, all chambers visible from the dorsal side, only those of the last-formed coil from the ventral; wall arenaceous; aperture, an arched slit on the inner margin of the ventral side of the chamber.

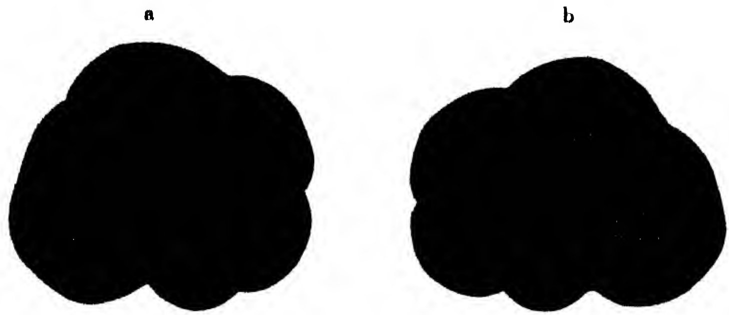
43. **Trochammina inflata** (MONTAGU).

(Text-fig. 43)

Rotalia inflata, WILLIAMSON, 1858, p. 50, pl. 4, figs. 93, 94.

Trochammina inflata, CARPENTER, PARKER and JONES, 1862, p. 141, pl. 11, fig. 5; H. B. BRADY, 1864, p. 467; 1870, p. 289; 1884, p. 338, pl. 41, fig. 4a–c; GOËS, 1894, p. 29, pl. 6, figs. 222–224; MILLETT, 1899, p. 364; KIAER, 1900, p. 44; SIDEBOTTOM, 1905, p. 6, pl. 1, fig. 9; HERON-ALLEN and EARLAND, 1909, p. 324; CUSHMAN, 1910, p. 121, text-fig. 188a, b; HERON-ALLEN and EARLAND, 1913 (c), p. 52; 1915, p. 620; 1916 (a), p. 227; CUSHMAN, 1920 (a), p. 73.

Description. — Test free, dorsal face flattened, ventral one concave with an umbilical region, composed of about three convolutions, of which the outer one has five or six inflated subglobular chambers, all chambers visible from the dorsal side, but only those of the last-formed coil visible from the ventral side; sutures distinct with deep depressions; wall consisting of fine sand grains smoothly united together with much cement; aperture elongate, arched, opening at the ventral side of the final chamber; color reddish brown or yellowish



Tex-fig. 43. *Trochammina inflata* (MONTAGU). ×50.
a, dorsal view. b, ventral view.

grey, dark color at the central portion, fading gradually towards the last-formed chamber.

Diameter, up to 0.80 mm.

Localities. — All stations, 4–33 fathoms.

Remarks. — This species is common in Mutsu Bay, and is represented by specimens of two types of color of the test: in the first type it is reddish brown on the whole and is dark greyish in the initial portion, while in the second it is light grey in general and is dark in the central coils. CUSHMAN (1910) formerly detected this species in the Nero material taken from off the coast of Japan.

44. Trochammina globigeriniformis (PARKER and JONES).

(Text-fig. 44)

Globigerina bulloides, WILLIAMSON, p 1858, p. 56, pl. 5, figs. 116–118.

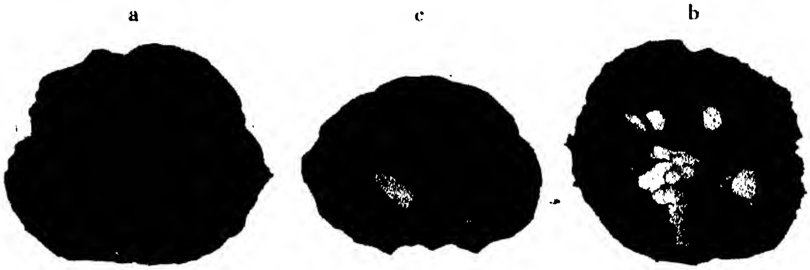
Haplophragmium globigeriniforme, H. B. BRADY, 1881 (b), p. 12; 1884, p. 312, pl. 35, figs. 10, 11; EGGER, 1893, p. 681, pl. 51, figs. 30, 31; GOËS, 1894, p. 22, pl. 5, figs. 128–133; CHAPMAN, 1895, p. 16; GOËS, 1896, p. 30; FLINT, 1897, p. 277, pl. 21, fig. 1; MILLETT, 1899, p. 361; KIAER, 1900, p. 43; BAGG, 1908, p. 126; HERON-ALLEN and EARLAND, 1913 (c), p. 46; 1915, p. 614; 1916 (a), p. 224.

Ammoglobigerina bulloides, EIMER and FICKERT, 1899, p. 704.

Trochammina globigeriniformis, CUSHMAN, 1910, p. 24, text-figs. 193–195; PEARCEY, 1914, p. 1011; CUSHMAN, 1920 (a), p. 78, pl. 16, figs. 5, 6; 1921, p. 96, pl. 11, figs. 4, 5; 1927 (a), p. 141; HADA, 1929, p. 11.

Description. — Test free or adherent, dorsal face convex, ventral one nearly flattened, consisting of about three convolutions composed

of a series of globular chambers increasing rapidly in size as added, four or five chambers building up the outer whorl and visible from below, while all chambers are visible from above; sutures depressed; wall coarsely arenaceous, but cemented firmly with an excess of cementing material; aperture somewhat arched, slit-like, at the central margin of the last-formed chamber on the ventral side, often covered with the clear shell substance; color reddish brown.



Text-fig. 44. *Trochammina globigeriniformis* (PARKER and JONES). ×50.
a, dorsal view. b, ventral view. c, side view.

Diameter, about 0.70 mm.

Localities. — It was found at all stations, 4–33 fathoms, where the collections were made.

Remarks. — This species has been widely reported from comparatively deep waters. It is very common in Mutsu Bay, and is found either free or attached to foreign substance. The free forms are in most cases larger than the attached. For this species CUSHMAN (1910) reported a great number of localities distributed in the waters adjacent to Japan. I (1929) have also obtained this species from the inlet of Oshoro and from the port of Nemuro in Hokkaido.

Subfamily GLOBOTEXTULARIINAE.

Test irregularly spiral, the chamber globose; aperture in the open umbilical area.

Genus NOURIA HERON-ALLEN and EARLAND, 1914.

Test free, of several chambers, irregularly arranged; wall arenaceous; aperture simple, terminal.

45. **Nouria polymorphinoides** Heron-Allen and Earland.

(Text-fig. 45)

Nouria polymorphynoides, Heron-Allen and Earland, 1914, p. 376, pl. 37, figs. 1–15; Cushman, 1920 (b), p. 601, pl. 75, figs. 4, 5; 1927 (a), p. 142.

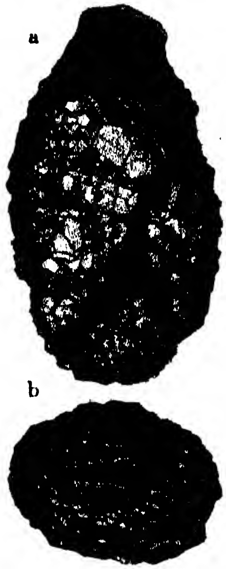
Description. — Test elongate, oblong, somewhat compressed, the apertural end produced; chambers few, irregular, asymmetrically arranged, separated by scarcely visible sutures; cavities partitioned by imperfect septa; wall composed of sand grains, rather neatly cemented with dark greyish brown cement; aperture opening as a narrow elliptical orifice.

Length, up to 0.95 mm.

Localities. — All stations, 4–33 fathoms.

Remarks. — A few specimens of this species have been found in the material from every station of Mutsu Bay, where collections were made. They are not so large and are not so irregular in shape as the specimens of the Kerimba Archipelago first described by Heron-Allen and Earland (1914).

a



b

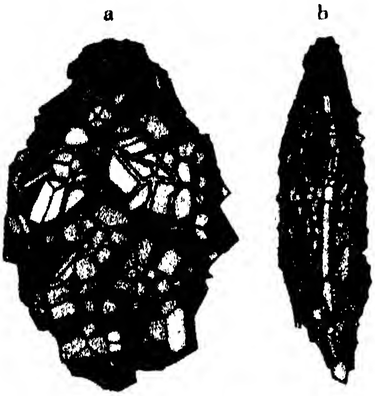
Text-fig. 45. *Nouria polymorphinoides* Heron-Allen and Earland. ×60.
a, side view.
b, apertural view.

46. **Nouria textulariformis**, n. sp.

(Text-fig. 46)

Description. — Test usually oblong in side view, much compressed, broadest in the middle, apertural end somewhat drawn out into a short neck; periphery acute; chambers several, arranged biserially; sutures scarcely depressed; wall rather thin and delicate, composed of sand grains finely united together with yellowish grey cement; aperture a long, narrow opening; color generally light grey, yellowish brown at the apertural end.

Length, about 1.15 mm; breadth, about 0.60 mm; thickness, about 0.22 mm.



Text-fig. 46. *Nouria textulariformis*, n. sp. ×40.
a, side view. b, peripheral view.

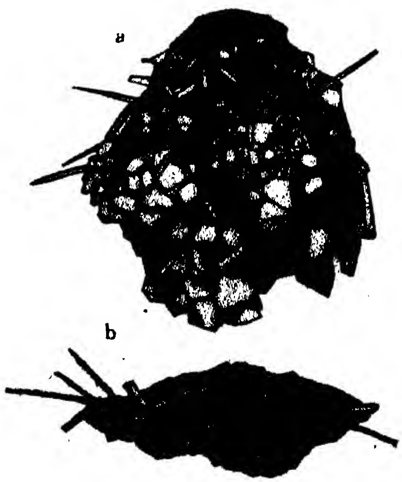
Localities. — Off Yunoshima, 18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — This new species is comparatively rare in Mutsu Bay. Several specimens have been detected in the bottom material from that region. The test is so fragile that it is difficult to obtain complete individuals. This species is easily distinguishable from other allied forms by the compressed test and by the chambers arranged in a *Textularia*-like manner.

47. **Nouria tenuis**, n. sp.
(Text-fig. 47)

Description. — Test irregular in shape, much compressed, a little longer than broad, broadest about in the middle, composed of a few chambers arranged biserially, partitioned by imperfect septa; peripheral margin sharply angular, from which long spicules usually projecting out; sutural lines indistinct, slightly depressed; wall neatly arenaceous, sometimes thin; aperture comparatively large, elongate, situated transversely at the terminal end of the last-formed chamber; color usually light grey.

Length, 0.73–1.00 mm; breadth. 0.62–0.81 mm; thickness, about 0.27 mm.



Text-fig. 47. *Nouria tenuis*, n. sp. ×40.
a, side view. b, apertural view.

Localities. — This from is commonly found in the material

from Mutsu Bay. It is not close to any of the established species, so far as I am aware. The wall in the specimens obtained from rather deep water of the bay is thin and somewhat translucent probably being composed of mica flakes. It is striking that a number of long sponge spicules are projected from the periphery of the test in various directions in most individuals. This new species differs from *Nouria textulariformis* in the broader test and in the longer aperture.

Family **Lagenidae.**

Test vitreous, with a glassy lustre; chambers simple, neither biserial, trochoid, nor irregularly spiral, planispiral when coiled; wall calcareous with very fine perforations; aperture typically radiate but in a few genera simple, in the radiate apertured forms with a small chamberlet below the radiate aperture opening into the main chamber by a simple rounded orifice.

Subfamily NODOSARIINAE.

Test multilocular.

Genus DENTALINA D'ORBIGNY, 1826.

Test arcuate, elongate, of numerous chambers in a linear series; sutures usually oblique, at least in the early portion; aperture radiate, at least early stages, at or near the periphery but aproaching to the center in the last chambers.

48. **Dentalina communis** D'ORBIGNY.

(Text-fig. 48)

Dentalina communis, H. B. BRADY, 1870, p. 295.

Nodosaria communis, GOËS, 1882, p. 26, pl. 1, figs. 11–16; H. B. BRADY, 1884, p. 504, pl. 62, figs. 19–22; EGGER, 1893, p. 150, pl. 11, figs. 22–24; GOËS, 1894, p. 67, pl. 12, figs. 667–669; CHAPMAN, 1895, p. 30; GOËS, 1896, p. 61, pl. 6, fig. 1; FLINT, 1897, p. 310, pl. 56, fig. 2; KIAER, 1900, p. 35; SIDEBOTTOM, 1907, p. 1; CUSHMAN, 1913, p. 54, pl. 28, figs. 1, 2; HERON-ALLEN and EARLAND, 1913 (c), p. 92; 1916 (a), p. 256; 1916 (b), p. 47; CUSHMAN, 1920 (b), p. 611; 1921, p. 192, pl. 34, fig. 7; 1923, p. 75, pl. 12, figs. 3, 4, 15–17.

Description. — Test elongate, slender, slightly curved, composed of numerous chambers; sutures oblique; surface smooth, occasionally translucent: aperture radiate, terminal.

Length, up to 3.60 mm.

Localities. — Off Yunoshima, 15 fathoms; off Futagojima, 23 fathoms.

Remarks. — This is one of the comparatively rare species in Mutsu Bay, but is widely distributed in other seas. CUSHMAN (1913) recorded the specimens obtained at many stations off the coast of Japan. As *Dentalina communis* is the name applied to the species which has a smooth test with the oblique sutural lines. Several forms of somewhat different nature, however, are included under this name. Some diversities in this feature of the test are noticeable also among the specimens taken from Mutsu Bay. In the typical form the test consists of thin and translucent wall and is provided with an eccentric aperture situated at the tip of a short, neck-like projection, while in those from our collections the test consists of a series of unequal chambers, with wall thick and opaque.

Text-fig. 48. *Dentalina communis* D'ORBIGNY. ×50.

49. **Dentalina consobrina** D'ORBIGNY, var. emaciata REUSS.

(Text-fig. 49)

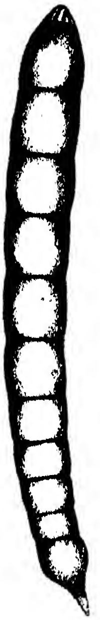
Nodosaria consobrina, var. emaciata, H. B. BRADY, 1884, p. 502, pl. 62, figs. 25, 26; FLINT, 1897, p. 310, pl. 56, fig. 1; CUSHMAN, 1913, p. 56, pl. 27, fig. 9; 1921, p. 195, pl. 34, fig. 8, pl. 35, fig. 1; 1923, p. 78, pl. 15, figs. 3–5.

Description. — Test elongate, slender, slightly arcuate, consisting of numerous short chambers, sometimes the first one tapering into a spine; sutures nearly transverse, slightly depressed; surface smooth; aperture radiate, terminal.

Length, 1.00–2.00 mm.

Localities. — Off Yunoshima, 18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — This variety is of rare occurrence in Mutsu Bay. As shown in the figure, the specimens taken from Mutsu Bay are provided with a short spine at the initial end, but the most specimens previously recorded from other localities are rounded at this end lacking the spine. Moreover, the specimens from Mutsu Bay are smaller than those obtained from other seas. CUSHMAN (1913) noted this variety without a spine from the Albatross material collected at two stations off Japan.



Text-fig. 49. *Dentalina consobrina* D'ORBIGNY, var. *emaciata* REUSS. ×45.

Text-fig. 50. *Dentalina mutsui*, n. sp. ×40.

50. **Dentalina mutsui**, n. sp.
(Text-fig. 50)

Description. — Test slender, elongate, tapering gradually towards the initial end which has a stout spine, usually slightly curved; apertural end drawn out into a short neck; sutures impressed, distinct; surface ornamented by about ten raised longitudinal costae which do not run along the entire length of the test; aperture radiate, terminal, usually eccentric.

Length, up to 3.65 mm.

Localities. — Off Yunoshima, 15 fathoms; off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms.

Remarks. — This species is common in Mutsu Bay. It is closely allied with *Dentalina flintii* in the general contour, but differs from the latter in fewer costae which do not cover the entire length of the test but fade out on the final chambers. *D. mutsui* has also a somewhat longer spine more abruptly set off from the initial chamber.

Genus NODOSARIA LAMARCK, 1812.

Test with the chambers in a straight linear series, the chambers distinct, not strongly embracing; sutures normally at right angles to the axis; wall calcareous, finely perforate, glassy; aperture central and terminal, radiate, often with a chamberlet below with a rounded opening into the main cavity of the chamber.

51. Nodosaria simplex SILVESTRI.

(Text-fig. 51)

Nodosaria simplex, H. B. BRADY, 1884, p. 496, pl. 62, figs. 4, 5; EGGER, 1893, p. 148, pl. 11, fig. 6; FLINT, 1897, p 309, pl. 55, fig. 2; CUSHMAN, 1913, p. 49, pl. 28, fig. 5; 1921, p. 186; 1923, p. 68, pl. 12, fig. 14, pl. 14, fig. 10.

Text-fig. 51. *Nodosaria simplex* SILVESTRI. ×120.

Description. — Test usually composed of two chambers, the first subglobular with a short spine, the second elongate and drawn out into a slender neck with the radiate aperture; sutures depressed; wall smooth, somewhat translucent.

Length, about 0.45 mm.

Localities. — Off Yunoshima, 18 fathoms; off Futagojima, 23 fathoms.

Remarks. — This species is rather rare in Mutsu Bay. I have obtained three specimens dealt with in the present report. The one which is shown in the figure is typical in shape, but other two are of very small size and it is doubtful whether they are certainly the adult form of this species or the young forms of other species.

52. Nodosaria pyrula D'ORBIGNY.

Nodosaria pyrula, H. B. BRADY, 1884, p. 497, pl. 62, figs. 10–12; EGGER, 1893, p. 153, pl. 11, figs. 14, 15; CHAPMAN, 1895, p. 30; FLINT, 1897, p. 309, pl. 55, fig. 4; KIAER, 1900, p. 35; MILLETT, 1902, p. 514; CUSHMAN, 1913, p. 49, pl. 26, figs. 1–3; HERON-ALLEN and EARLAND, 1913 (c), p. 92; 1916 (a), p. 256; 1916 (b), p. 47; CUSHMAN, 1920 (b), p. 611; 1921, p. 187, pl. 33, figs. 3–5; 1923, p. 69, pl. 16, figs. 1–4; 1927 (a), p. 143.

Description. — Test elongate, slender, composed of numerous pyriform chambers with the long tubular connections; initial chamber spindle-shaped, differing from the others; circular in transverse section; surface smooth; aperture usually rounded, situated at the tip of the long neck.

Diameter, 0.12–0.14 mm.

Localities. — Off Futagojima, 25 fathoms; near Ōshima, 23 fathoms.

Remarks. — Of this species the test is exceedingly delicate and moreover is very long at the stoloniferous connection. On account of this structural weakness the specimen is very easily broken into fragments, and thus it very difficult to obtain the complete specimens. H. B. BRADY (1884) and CUSHMAN (1913) already reported this species from off the coast of Japan.

53. Nodosaria pyrula D'ORBIGNY, var. semirugosa D'ORBIGNY.

(Text-fig. 52)

Nodosaria costulata, H. B. BRADY, 1884, p. 515, pl. 63, figs. 23–27; FLINT, 1897, p. 312, pl. 58, fig. 1.

Nodosaria semirugosa, MILLETT, 1902, p. 515, pl. 11, fig. 5; CUSHMAN, 1913, p. 50, pl. 26, figs. 4–8.

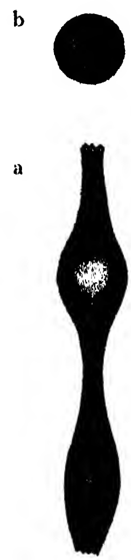
Nodosaria pyrula, var. *semirugosa*, CUSHMAN, 1921, p. 187, pl. 33, figs. 6, 7; 1923, p 70, pl. 16, fig. 5.

Description. — This variety differs from the typical form in the ornamentation of the test, which is provided with several costae of varying length, covering the basal portion of each chamber.

Diameter, about 0.13 mm.

Localities. — Off Futagojima, 25 fathoms.

Remarks. — In Mutsu Bay the variety is more rarely found than the typical form. I was also unable to obtain complete specimens in the material from the bay.



Text-fig. 52. *Nodosaria pyrula* D'ORBIGNY, var. *semirugosa* D'ORBIGNY. ×70.

a, side view.

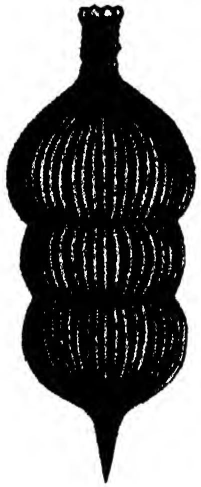
b, apertural view.

54. **Nodosaria scalaris** (BATSCH).

(Text-fig. 53)

Nodosaria scalaris, H. B. BRADY, 1870, p. 295; 1884, p. 510, pl. 63, figs. 28–31; EGGER, 1893, p. 152, pl. 11, figs. 40, 41; GOËS, 1894, p. 73, pl. 13, figs. 716–718; CHAPMAN, 1895, p. 32; GOËS, 1896, p. 60; KIAER, 1900, p. 36; MILLETT, 1902, p. 520, pl. 11, fig. 2; CUSHMAN, 1913, p. 58, pl. 24, fig. 7; HERON-ALLEN and EARLAND, 1913 (c), p. 93; 1916 (a), p. 257; 1916 (b), p. 47; CUSHMAN, 1920 (b), p. 613; 1921, p. 199, p.. 35, fig. 6; 1923, p. 81; IKARI, 1927, p. 12, pl. 1, fig. 17.

Description. — Test straight, composed of a few subglobular chambers, usually increasing rapidly in size as added, initial chamber with a short spine, final one drawn out into a cylindrical neck ornamented with several spiral ridges; sutures much depressed; surface marked with numerous fine longitudinal costae; aperture terminal.



Text-fig. 53. *Nodosaria scalaris* (BATSCH). ×50.

Length, about 1.20 mm.

Localities. — Off Yunoshima, 15 fathoms; off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms.

Remarks. — This species which has a worldwide distribution also occurs in Mutsu Bay. Previous records on the occurrence of this species off Japan were made by H. B. BRADY (1884) and by IKARI (1927). The former author obtained his specimens among the Challenger material from the Hyalonema-ground off the southern coast of Japan, while the later author secured his material from bottom sand taken at Misaki.

Genus GLANDULINA D'ORBIGNY, 1826.

Test similar to *Nodosaria*, but the chambers embracing, the last-formed one making up a large proportion of the surface of the test.

55. **Glandulina rotundata** REUSS.

(Text-fig. 54)

Nodosaria rotundata, H. B. BRADY, 1884, p. 491, pl. 61, figs. 17–19; FLINT, 1897,

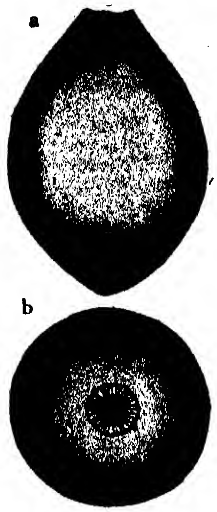
p. 308, pl. 54, fig. 6; CUSHMAN, 1913, p. 47, pl. 28, fig. 6; HERON-ALLEN and EARLAND, 1916 (a), p. 255; CUSHMAN, 1921, p. 185; 1922 (b), p. 32, pl. 4, fig. 1; 1923, p. 63.

Description. — Test oval, composed of a few chambers overlapping the predecessors, broadest in the middle; sutures not depressed, usually indistinct; aperture radiate at the slightly produced end of the terminal chamber; surface smooth and white.

Length, 0.66 mm; diameter, 0.45 mm.

Locality. — Off Yunoshima, 18 fathoms.

Remarks. — A single specimen has been found in the material from above station in Mutsu Bay. From the sea of Japan this species was only once reported by CUSHMAN (1913) from an Albatross station in 44 fathoms off Japan.



Text-fig. 54. *Glandulina rotundata* REUSS. ×60.
a, front view.
b, apertural view.

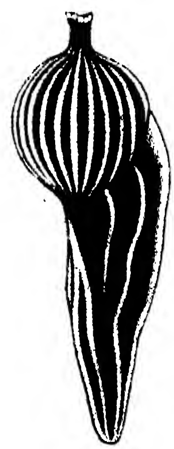
Genus AMPHICORYNE SCHLUMBERGER, 1881.

Test in the young like a compressed *Lenticulina* loosely coiled, the last-formed chambers like *Nodosaria*.

56. Amphicoryne falx JONES and PARKER.
(Text-fig. 55)

Amphicoryne falx, H. B. BRADY, 1884, p. 556, pl. 65, figs. 7–9.

Description. — Test elongate, composed of several chambers, early chambers somewhat compressed, having tendency to coil planispirally, last-formed chamber subglobular; sutures almost indistinct in the early portion; wall ornamented with numerous longitudinal costae less in number in the early compressed portion; aperture terminal, opening at the end of a tubular neck.



Text-fig. 55. *Amphicoryne falx* JONES and PARKER. ×75.

Length, about 0.75 mm.

Locality. — Off Futagojima, 23 fathoms.

Remarks. — It seems to be a rare species in Mutsu Bay as in other waters. I have found only two specimens in the material from this bay.

Subfamily LAGENINAE.

Test consisting of a single chamber; aperture typically radiate, but elliptical or rounded in many species.

Genus LAGENA WALKER and JACOB, 1798.

Test unilocular; aperture typically radiate, rounded or elliptical, terminal, central; wall vitreous, very finely perforate, variously ornamented; chambers typically without an internal tube.

57. Lagena laevis (MONTAGU).
(Text-fig. 56)

Lagena laevis, WILLIAMSON, 1848, p. 12, pl. 1, figs. 1, 2; H. B. BRADY, 1870, p. 292; 1881 (b), p. 14; 1884, p. 455, pl. 56, figs. 7, 9, 12; EGGER, 1893, p. 131, pl. 10, figs. 3-5; GOËS, 1894, p. 74, pl. 13, figs. 719–722; CHAPMAN, 1895, p. 26; GOËS, 1896, p. 51; FLINT, 1897, p. 306, pl. 53, fig. 6; KIAER, 1900, p. 37; CUSHMAN, 1913, p. 5, pl. 1, fig. 3, pl. 38, fig. 5; 1920 (b), p. 607; 1921, p. 173; 1923, p. 29, pl. 5, fig. 3; HERON-ALLEN and EARLAND, 1924, p. 624; HADA, 1929, p. 12.

Lagena vulgaris, WILLIAMSON, 1858, p. 4, pl. 1, figs. 5, 5a.

Text-fig. 56. *Lagena laevis* (MOTAGU). ×65.

Description. — Test typically flask-shaped, nearly circular in transverse section; wall usually smooth and translucent, sometimes opaque; aperture rounded at the end of a long tubular neck with a hyaline lip.

Length, 0.68 mm.

Locality. — Off Futagojima, 25 fathoms.

Remarks. — A single specimen shown in Text-fig. 56 was secured at the above station. Of this species there are many reports which

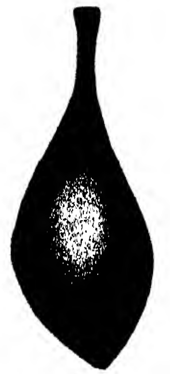
show its wide distribution. CUSHMAN (1913) recorded it at several of the Nero and of the Albatross stations located off the coast of Japan. I (1929) have also collected the species from the shallow water of Oshoro, Hokkaido.

58. Lagena clavata (D'ORBIGNY).
(Text-fig. 57)

Lagena laevis, var. *amphora*, WILLIAMSON, 1848, p, 12, pl. 1, figs. 3, 4.
Lagena vulgaris, var. *clavata*, WILLIAMSON, 1858, p. 5, pl. 1, fig. 6.
Lagena clavata, H. B. BRADY, 1884, p. 456; EGGER, 1893, p. 132, pl. 10, fig. 68; GOËS 1894, p. 75, pl. 13, figs. 725-727; KIAER, 1900, p. 38; MILLETT, 1901, p. 490; CUSHMAN, 1913, p. 9, pl. 2, fig. 3; HERON-ALLEN and EARLAND, 1913 (c), p. 80; 1915, p. 660, pl. 50, fig. 23; 1916 (a), p. 248; 1916 (b), p. 45; CUSHMAN, 1921, p. 174; 1923, p. 10, pl. 1, fig. 15.

Description. — Test elongate, fusiform, possessing a long slender neck with a hyaline lip at the oral end, sharp-pointed at the basal end, nearly circular in cross section; surface smooth; wall thin and translucent; aperture rounded at the end of the neck.

Length, 0.51 mm.



Text-fig. 57. *Lagena clavata* (D'ORBIGNY). ×90.

Remarks. — This species is very rare in Mutsu Bay: I have found only one specimen shown in Text-fig. 57. The test is slightly curved, and is not so slender as in the specimen obtained from off Great Britain and figured by WILLIAMSON (1858) and also in that reported by CUSHMAN (1923) from the Atlantic Ocean, but it is very similar in appearance to the specimens which were secured by CUSHMAN (1913, pl. 2, fig. 3) from the North Pacific.

59. Lagena gracillima (SEGUENZA).
(Text-fig. 58)

Lagena gracillima, H. B. BRADY, 1870, p. 292, pl. 11, figs. 6a–c; BÜTSCHLI, 1880–1882, p. 197, pl. 7, fig. 20; H. B. BRADY, 1881 (b), p. 14; 1884, p. 456, pl. 56, figs. 21, 22, 24–26; EGGER, 1893, p. 138, pl. 10, fig. 12; GOËS, 1894, p. 75, pl. 15, fig. 729; 1896, p. 52; FLINT, 1897, p. 306, pl. 53,

fig. 3; KIAER, 1900, p. 38; MILLETT, 1901, p. 491; CUSHMAN, 1913, p. 11, pl. 1, fig. 4; HERON-ALLEN and EARLAND, 1915, p. 660; 1916 (a), p. 248; 1916 (b), p. 45; CUSHMAN, 1921, p. 175; 1923, p. 23, pl. 4, fig. 5; 1927 (a), p. 144; IKARI, 1927, p. 12, pl. 1, fig. 13; HADA, 1929, p. 12.

Description. — Test elongate, fusiform, straight or slightly curved, broadest near the middle, each end tapering into a long tube and one with a hyaline lip, nearly circular in transverse section; wall more or less translucent; surface smooth.

Text-fig. 58. *Lagena gracillima* (SEGUENZA). ×80.

Length, about 0.85 mm.

Localities. — Off Yunoshima, 18 fathoms; off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This species is rare but widely distributed in all depths in Mutsu Bay. It comprises two diverse forms: one shown in Text-fig. 58 is comparatively short and curved, while the other is slender and straight. From the Japanese waters, it is formerly reported by CUSHMAN (1913) at two Albatross stations, by IKARI (1927) from the bottom sand taken at Misaki, and by myself from Oshoro and Nemuro in Hokkaido.

60. **Lagena elongata** (EHRENBERG).

(Text-fig. 59)

Lagena elongata, H. B. BRADY, 1884, p. 457, pl. 56, fig. 29; GOËS, 1894, p. 75, pl. 13, fig. 713; FLINT, 1897, p. 306, pl. 53, fig. 1; CUSHMAN, 1913, p. 12, p. 1, fig. 5; 1920 (b), p. 608; 1921, p. 175; 1923, p. 15, p. 3, fig. 4; 1927 (a), p. 144.

Lagena gracillima, H. B. BRADY, 1884, pl. 56, figs. 27, 28; GOËS, 1894, pl. 13, figs. 728, 730.

Description. — Test elongate, slender, main portion nearly cylindrical, both ends drawn out into a long tube, apertural one with a lip; wall smooth, somewhat translucent; aperture usually rounded.

Length, up to 1. 50 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–

25 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks.—This species is rather rare. It is longer than any other species of *Lagena* found in Mutsu Bay, as far as examined in the present work. CUSHMAN (1913) obtained this species from several stations off Japan, ranging in depth from 44 to 649 fathoms.

61. Lagena semistriata WILLIAMSON.
(Text-fig. 60)

Lagena striata, var. *semistriata*, WILLIAMSON, 1848, p. 14, pl. 1, figs. 9, 10.
Lagena vulgaris, var. *semistriata*, WILLIAMSON, 1858, p. 6, pl. 1.
Lagena semistriata, H. B. BRADY, 1870, p. 293; 1881 (b), p. 14; 1884, p. 465, pl. 57, figs. 14, 16, 17; EGGER, 1893, p. 135, pl. 10, figs. 34, 39; GOES, 1894, p. 76, pl. 13, fig. 737; KIAER, 1900, p. 38; MILLETT, 1901, p. 486, pl. 8, figs. 2, 3; SIDEBOTTOM, 1906, p. 3; HERON-ALLEN and EARLAND, 1909, p. 424; 1913 (c), p. 78; PEARCEY, 1914, p. 1018; HERON-ALLEN and EARLAND, 1915, p. 658; 1916 (a), p. 245; 1916 (b), p. 45; CUSHMAN, 1920 (b), p. 610; 1921, p. 179; 1923, p. 50, pl. 9, fig. 15.


Text-fig. 59. *Lagena elongata* (EHRENBERG). ×70.


Text-fig. 60. *Lagena semistriata* WILLIAMSON. ×90.

Description. — Test elongate, fusiform or oval, apertural end drawn out into a slender tubular neck with a hyaline lip, opposite end rounded, or truncate, circular in cross-section; wall usually translucent; surface ornamented with raised costae at the basal portion, those not reaching the middle of the test; aperture simple, nearly rounded at the end of a long neck.

Length, up to 0.68 mm.

Localities.—Off Futagojima, 25 fathoms; between Ōshima and

Bentenjima, 30–33 fathoms.

Remarks. — I have a few specimens taken from Mutsu Bay: each differing in the features of the costae found at the base of the test.

62. **Lagena gracilis** WILLIAMSON.

(Text-fig. 61)

Lagena vulgaris, var. *gracilis*, WILLIAMSON, 1858, p. 7, pl. 1, figs. 12, 13.

Lagena gracilis, WILLIAMSON, 1848, p. 13, pl. 1, fig. 5; H. B. BRADY, 1881 (b), p. 14; 1884, p. 464, pl. 58, figs. 2, 3, 7–9, 19, 22, 23; EGGER, 1893, p. 136, pl. 10, figs. 25, 49; GOËS, 1894, p. 77, pl. 13, fig. 738; CHAPMAN, 1895, p. 27; KIAER, 1900, p. 38; MILLETT, 1901, p. 482, pl. 8, figs. 12–14; CUSHMAN, 1913, p. 24, pl. 8, figs. 5, 6; HERON-ALLEN and EARLAND, 1913 (c), p. 81; 1916 (a), p. 248; 1916 (b), p. 45; CUSHMAN, 1921, p. 181; 1923, p. 22, pl. 4, figs. 3, 4; 1927 (a), p. 144.

Text-fig. 61. *Lagena gracilis* WILLIAMSON. ×70.

Description. — Test elongate, fusiform, straight or curved, broadest in the middle, drawn out into a long tubular neck at the oral end, pointed at the basal end; nearly circular in transverse section; on the surface about twelve fine longitudinal costae extending from the apertural end to the basal end; aperture terminal, rounded.

Length, about 0.75 mm.

Localities. — Off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This species is found everywhere in Mutsu Bay. From the sea surrounding Japan it was recorded by CUSHMAN (1913) from many Nero stations distributed between Yokohama and Guam.

63. **Lagena distoma** PARKER and JONES.

(Text-fig. 62)

Lagena laevis, var. *striata*, PARKER and JONES, 1857, p. 278, pl. 11, fig. 24.

Lagena distoma, H. B. BRADY, 1864, p. 467, pl. 48, fig. 6; 1870, p. 293; 1881 (b), p. 14; 1884, p. 461, pl. 58, figs. 11–15; GOËS, 1894, p. 77, pl. 13, figs. 739, 740; CHAPMAN, 1895, p. 27; GOËS, 1896, p. 53; FLINT, 1897, p. 306, pl. 53, fig. 5; KIAER, 1900, p. 38; CUSHMAN, 1913, p. 22, pl. 13,

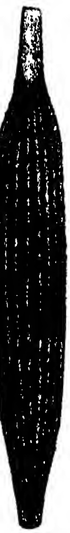
figs. 1, 2; PEARCEY, 1914, p. 1017; HERON-ALLEN and EARLAND, 1916 (a), p. 248; CUSHMAN, 1923, p. 14, pl. 13, figs. 2, 3.

Description. — Test elongate, cylindrical or fusiform, sides of the test nearly parallel in the middle part, drawn out into long slender tube at both ends, apertural end with a hyaline lip; wall somewhat translucent; surface marked with numerous fine longitudianal costae; aperture terminal, rounded.

Length, about 0.85 mm.

Localities. — Off Futagojima, 25 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — I have obtained several specimens from the bottom material taken from Mutsu Bay. This species is reported by H. B. BRADY (1884) from the Challenger material and by CUSHMAN (1913) from Nero material, both being collected from off Japan.



Text-fig. 62. *Lagena distoma* PARKER and JONES. ×120.

64. Lagena striata (D'ORBIGNY).

Lagena striata, H. B. BRADY, 1870, p. 293; 1884, p. 460, pl. 57, figs. 22, 24; EGGER, 1893, p. 135, pl. 10, figs. 21–23; GOËS, 1894, p. 75, pl. 13, figs. 735, 736; KIAER, 1900, p. 38; MILLETT, 1901, p. 487; SIDEBOTTOM, 1906, p. 2; CUSHMAN, 1913, p. 19, pl. 7, figs. 4, 5; HERON-ALLEN and EARLAND, 1913 (c), p. 78; PEARCEY, 1914, p. 1017; HERON-ALLEN and EARLAND, 1916 (a), p. 246; 1916 (b), p. 45; CUSHMAN, 1920 (b), p. 609; 1921, p. 177; 1923, p. 54, pl. 10, fig. 9; CUSHMAN and WICKENDEN, 1929, p. 6, pl. 3, figs. 4a, b; HADA, 1929, p. 12.

Description. — Test flask-shaped, chamber globular, oral end tapering into long tubular neck with a hyaline lip, aboral end rounded; circular in transverse section; surface ornamented with numerous longitudinal costae extending from the base to the apertural end; neck often having a spiral costa; aperture terminal, rounded.

Length, about 0.35 mm.

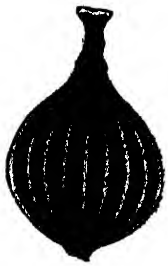
Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This species is less common in Mutsu Bay. Judging

from numerous records of this species it seems to be widely distributed and common in comparatively shallow waters. CUSHMAN (1913) reported specimens of this species from three Albatross stations off Japan.

65. **Lagena striata** (D'ORBIGNY), var. **strumosa** REUSS.
(Text-fig. 63)

Lagena striata, var. *strumosa*, CUSHMAN, 1913, p. 20, pl. 7, figs. 7–10; 1921, p. 178.



Text-fig. 63. *Lagena striata* (D'ORBIGNY), var. *strumosa* REUSS. ×100.

Description. — This variety differs from the typical species in having a stout spine at the basal end, in the smaller number of costae, and in the shorter neck.

Length, about 0.40 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — The variety usually occurs in company with the typical from in Mutsu Bay, where the specimens show some variation in size and shape. From the North Pacific about Japan CUSHMAN (1913) frequently obtained this variety from Albatross stations ranging in depth from 84 to 440 fathoms.

66. **Lagena substriata** WILLIAMSON.
(Text-fig. 64)

Lagena substriata, WILLIAMSON, 1848, p. 15, pl. 2, fig. 12; CUSHMAN, 1923, p. 56, pl. 10, fig. 11; 1927 (a), p. 145.

Lagena vulgaris, var. *substriata*, WILLIAMSON, 1858, pl. 1, fig. 14; CUSHMAN, 1913, p. 20, pl. 8, figs. 1–3.

Text-fig. 64. *Lagena substriata* WILLIAMSON. ×120.

Description. — Test elongate, main portion of the test nearly cylindrical, broadest in the middle, basal end rounded; circular in cross section; wall thin, somewhat translucent; surface ornamented with numerous fine longitudinal costae; aperture terminal, opening at the end of a long and slender neck.

Length, about 0.40 mm.

Locality. — Between Ōshima and Bentenjima, 33 fathoms.

Remarks. — It seems to be a very rare species in Mutsu Bay judging from the fact that only two specimens were obtained there. In so far as I am aware, this is the first record of this species from the neighbouring seas of Japan.

67. Lagena sulcata (WALKER and JACOB).

(Text-fig. 65)

Lagena sulcata, H. B. BRADY, 1870, p. 291; 1881 (b), p. 141; 1884, p. 462, pl. 57, figs. 23, 34; EGGER, 1893, p. 136, pl. 10, fig. 73; GOËS, 1894, p 78, pl. 13, fig. 744; CHAPMAN, 1895, p. 27; FLINT. 1897, p. 307, pl. 53, fig. 7; KIAER, 1900, p. 39; SIDEBOTTOM, 1906, p. 3; HERON-ALLEN and EARLAND, 1909, p. 423; CUSHMAN, 1913, p. 22, pl. 9, fig. 2; HERON-ALLEN and EARLAND, 1913 (c), p. 79; 1916 (a), p. 246; 1916 (b), p. 45; CUSHMAN, 1920 (b), p. 609; 1921, p. 179; 1923, p. 57, pl. 11, fig. 1; 1927 (a), .p. 145.

Description. — Test flask-shaped, chamber subglobular, ornamented with plate-like costae running along the entire length of the chamber, some of them often extending even into a long cylindrical neck; aperture terminal, usually rounded, surrounding by a lip.

Text-fig. 65. *Lagena sulcata* (WALKER and JACOB). ×80.

Length, up to 0.63 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms; between Ōshima and Bentenjima, 33 fathoms.

Remarks. — This species is common in Mutsu Bay, the specimens being more easily found than in the case of any other species of the genus. The existence of this species in the adjacent waters of Japan has been reported by only CUSHMAN (1913) from two Albatross stations, respectively 44 and 282 fathoms deep.

68. Lagena sulcata (WALKER and JACOB), var. interrupta WILLIAMSON.

(Text-fig. 66)

Lagena vulgaris, var. *interrupta*, WILLIAMSON, 1858, p. 7, pl. 1, fig. 11.

Lagena sulcata, var. *interrupta*, H. B. BRADY, 1884, p. 463, pl. 57, figs. 25, 27; SIDEBOTTOM, 1906, p. 3.

Lagena interrupta, EGGER, 1893, p. 136, pl. 10, fig. 32.

Description. — This variety differs from the typical species in the unequal length of costae, shorter costae usually being interposed between longer ones and not more than half the length of the longer costae.

Length, about 0.55 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — In Mutsu Bay the variety is less frequently found than the typical form, and is represented by variously shaped specimens. Hitherto there were no records on the occurrence of this variety in the waters adjacent to Japan.

Text-fig. 66. *Lagena sulcata* (WALKER and JACOB), var. *interrupta* WILLIAMSON. ×110.

69. **Lagena orbignyana** (SEGUENZA) var.

(Text-fig. 67)

Description. — Test compressed, nearly circular in front view, oral end slightly tapering; central portion smooth, convex; periphery surrounded by three raised keels connected with each other by many short ridges; aperture small, opening at the scarcely produced oral end.

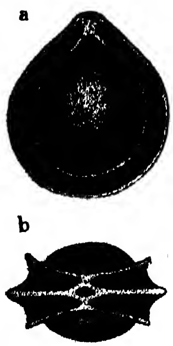
Length, about 0.25 mm.

Locality. — Between Futagojima and Ōshima, 18–21 fathoms.

Remarks. — This variety is rarely found in Mutsu Bay.

a

b



Text-fig. 67. *Lagena orbignyana* (SEGUENZA), var. ×100.
a, side view.
b, apertural view.

Family **Polymorphinidae.**

Test spiral or sigmoid in the earlier stages, later in some genera becoming biserial, uniserial, or irregularly branching; chambers simple, not labyrinthic; wall cal-

careous, very finely perforate; aperture radiate except in the moro degenerate genera where there is a simple, rounded opening.

Subfamily POLYMORPHININAE.

Test with the chambers in a closed spiral or sigmoid series at least in the early stages, later becoming in some genera biserial or uniserial.

Genus GUTTULINA D'ORBIGNY, 1826.

Test rounded, spherical to fusiform; chambers spheroidal to ellipsoidal or clavate, not at all compressed, arranged more or less in an elongate spiral series so that they form generally a clockwise close sigmoid series viewed from the base, successive chambers added in planes less than 180°, three or four chambers in a cycle; sutures distinct; aperture radiate.

70. Guttulina communis D'ORBIGNY.
(Text-fig. 68)

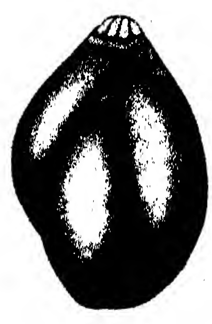
Polymorphina communis, H. B. BRADY, PARKER and JONES, 1870, p. 224, pl. 39, fig. 10a, b; H. B. BRADY, 1870, p. 297; 1884, p. 568, pl. 72, fig. 19; CHAPMAN, 1895, p. 34; FLINT, 1897, p. 319, pl. 67, fig. 6; SIDEBOTTOM, 1907, p. 11; HERON-ALLEN and EARLAND, 1913 (c), p. 101; 1916 (a), p. 265; 1916 (b), p. 48; CUSHMAN, 1923, p. 147, pl. 40, figs. 1, 2; HADA, 1929, p. 12.

Description. — Test ovate, slightly compressed, apertural end somewhat drawn out, initial end rounded; chambers few in number, inflated; sutures distinct, depressed; surface smooth; aperture terminal, radiate.

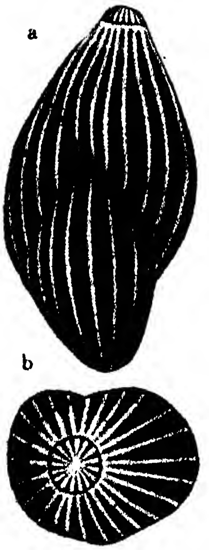
Length, about 0.60 mm.

Locality. — Off Futagojima, 25 fathoms.

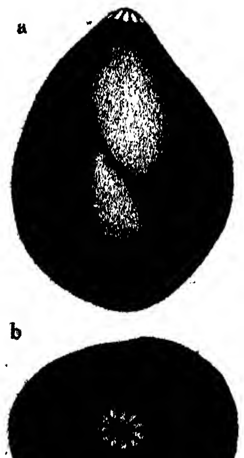
Remarks. — Only two small specimens have been found in the collection from Mutsu Bay. The specimens (1929) from the inlet Oshoro, Hokkaido, which I have previously reported were also of small size.



Text-fig. 68. *Guttulina communis* D'ORBIGNY. ×65.



Text-fig. 69. *Guttulina regina* H. B. BRADY, PARKER and JONES. ×45.
a, side view.
b, apertural view.



Text-fig. 70. *Guttulina gibba* D'ORBIGNY. ×90.
a, side view.
b, apertural view.

71. Guttulina regina H. B. BRADY, PARKER and JONES.

(Text-fig. 69)

Polymorphina regina, H. B. BRADY, PARKER and JONES, 1970, p. 241, pl. 41, fig. 32a, b; H. B. BRADY, 1884, p. 571, pl. 73, figs. 11–13; EGGER, 1893, p. 118, pl. 9, figs. 45, 50, 51; MILLETT, 1903, p. 265; BAGG, 1908, p. 139; HERON-ALLEN and EARLAND, 1909, p. 435; CUSHMAN, 1913, p. 91, pl. 41, figs 6, 7; HERON-ALLEN and EARLAND, 1915, p. 673; CUSHMAN, 1920 (b), p. 619; 1921, p. 263; 1922 (b), p. 33, pl. 4, figs. 5, 6; 1923, p. 159.

Description. — Test elongate, ovate or fusiform; chambers several, inflated; sutures distinct, deeply depressed; wall ornamented with numerous longitudinal costae on the surface of each chamber; aperture radiate, terminal.

Length, 0.85–1.20 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 23 fathoms.

Remarks. — This characteristic species is commonly found in the materials from above mentioned stations in Mutsu Bay. There exists no previous published record on the occurrence of this species in the waters off Japan.

72. Guttulina gibba D'ORBIGNY.

(Text-fig. 70)

Polymorphina gibba, H. B. BRADY, PARKER and JONES, 1870, p. 216, pl. 39, fig. 2a, b; H. B. BRADY, 1884, p. 561, pl. 71, fig. 12a, b; GOËS, 1894, pl. 9, figs. 520, 522; KIAER, 1900, p. 41; SIDEBOTTOM, 1907, p. 10, pl. 2, figs. 15-17; CUSHMAN, 1913, p. 90, pl. 38, fig. 1; HERON-ALLEN and EARLAND, 1913 (c), p. 100; PEARCEY,

1914, p. 1023; HERON-ALLEN and EARLAND, 1916 (a), p. 265; 1916 (b), p. 48; CUSHMAN, 1920 (b), p. 618; 1921, p. 267; 1922 (b), p. 34, pl. 4, fig. 9; 1923, p. 150.

Description. — Test globular nearly circular in front view, very slightly compressed, composed of a few visible chambers; sutures distinct, but not depressed; surface smooth, sometimes polished; aperture radiate, situated at the apertural end slightly drawn out from the main body.

Length, about 0.45 mm.

Localities. — Off Yunoshima, 10–18 fathoms; between Ōshima and Bentenjima, 33 fathoms.

Remarks. — A few specimens of this species were found in the material taken from Mutsu Bay, showing some variation. CUSHMAN (1913) reported the specimens of this species from a single station in 44 fathoms off Japan.

Genus PSEUDOPOLYMORPHINA CUSHMAN and OZAWA, 1928.

Test elongate, often somewhat compressed; chambers rounded, generally as long as broad, arranged in a closed sigmoid series in the earlier stages, becoming biserial in the adult; sutures distinct, depressed; aperture radiate.

73. Pseudopolymorphina soldanii (D'ORBIGNY).

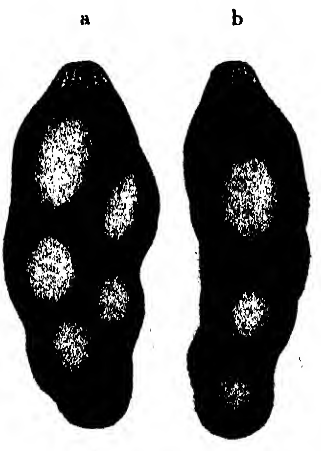
(Text-fig. 71)

Polymorphina soldanii, H. B. BRADY, PARKER and JONES, 1870, p. 235, pl. 40, fig. 20; HADA, 1929, p. 12.

Description. — Test elongate, compressed, early chambers arranged in a closed sigmoid series, later ones arranged biserially: chambers usually numerous, inflated; sutures distinct, depressed; wall opaque or somewhat translucent; aperture radiate, terminal.

Length, up to 2.00 mm.

Localities. — Off Yunoshima, 10–18



Text-fig. 71. *Pseudopolymorphina soldanii* (D'ORBIGNY). ×30. a, side view. b, peripheral view.

fathoms; off Futagojima, 17–25 fathoms; near Ōshima 23 fathoms.

Remarks. — This species is exceedingly common, and is the largest form among the members of the family *Polymorphinidae* found in Mutsu Bay. The young forms somewhat resemble the species of the genus *Guttulina*, but the adult specimens differ obviously from these in the arrangement of the later chambers which is biserial.

Genus DIMORPHINA D'ORBIGNY, 1826.

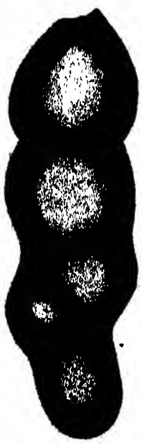
Test cylindrical; chambers rounded, arranged at first in a close sigmoid series, becoming uniserial in the adult; sutures distinct, depressed.

74. Dimorphina tuberosa D'ORBIGNY.

(Text-fig. 72)

Dimorphina tuberosa, H. B BRADY, PARKER and JONES, 1870, p. 249, pl. 42, figs. 39a, b.

Description. — Test elongate, nearly straight; chambers few in number, arranged in a closed sigmoid series in the early portion, later portion uniserial, inflated; sutures distinct, depressed; surface smooth; aperture terminal, radiate.



Text-fig. 72. *Dimorphina tuberosa* D'ORBIGNY. ×65.

Length, about 0.85 mm.

Locality. — Off Futagojima, 23–25 fathoms.

Remarks. — Rare, only two specimens referred to this species have been found in the bottom material from Mutsu Bay.

Genus SIGMOMORPHA CUSHMAN and OZAWA, 1928.

Test flattened, oval to subelliptical in side view; chambers elongate, angular in transverse section, arranged at first like *Guttulina*, then open sigmoidal; sutures distinct, depressed.

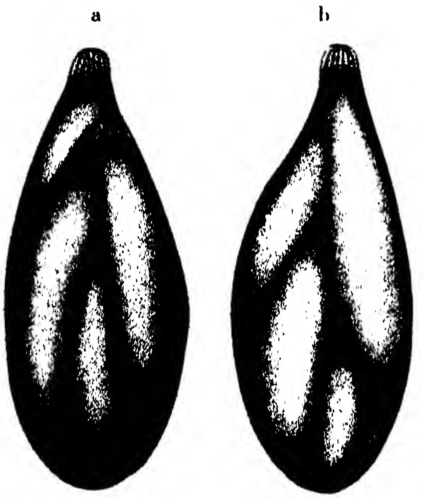
75. Sigmomorpha ozawai, n. sp.

(Text-figs. 73, 74)

Description. — Test elongate, compressed, usually twice as long as broad, broadest nearly at the middle, basal end rounded, tapering to the apertural end, which somewhat drawn out in a neck-like process; chambers elongate, narrow, curved, angular in transverse section, later chambers arranged in an open sigmoid series and in the adult sometimes not reaching the base; sutures distinct, depressed; wall smooth, translucent; aperture terminal, radiate, sometimes more or less eccentric.

Length, up to 0.95 mm; breadth, up to 0.44 mm; thickness, about 0.22 mm.

Localities. — Off Yunoshima, 10-18 fathoms; off Futagojima, 17-25 fathoms; between Oshima and Bentenjima, 30-33 fathoms.



Text-fig. 73. *Sigmomorpha ozawai*, n. sp. a, b, side view.

Text-fig. 74. *Sigmomorpha ozawai*, n. sp. ×65. a, side view. b, basal view.

Remarks. — This new species is aboundant in Mutsu Bay, and shows a little variation in breadth. It differs from *Sigmomorpha sadoensis* in the elongate and compressed test and from *S. sawanensis* in the depressed sutures and in the features of the chambers, the

later ones not reaching to the base of the test. It may also be distinguished from *S. trilocularis* in the shape of the test and in the shapes of the chambers forming the test.

Genus SIGMOIDELLA CUSHMAN and OZAWA, 1928.

Test ovate to elliptical in side view, compressed; chambers elongate, angular, regularly arranged in open sigmoid series, gradually increasing in length in the later ones which include the ealier ones, but often the adult chambers not reaching the base; sutures distinct.

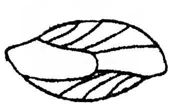
76. **Sigmoidella kagaensis** CUSHMAN and OZAWA.

(Text-fig. 75)

Sigmoidella kagaensis, CUSHMAN and OZAWA, 1928, p. 19, pl. 2, fig. 14; 1929, p. 76, pl. 13, fig. 15, pl. 16, fig. 9.

a

b



Text-fig. 75. *Sigmoidella kagaensis* CUSHMAN and OZAWA. ×35.
a, side view.
b, basal view.

Description.—Test elongate, compressed, basal end rounded, apertural one produced, peripheral margin subacute; chambers long, narrow, arranged in an open clock-wise sigmoid series, in side view one large chamber on the left of the test; sutures distinct, curved, generally not depressed; wall somewhat translucent; aperture radiate, terminal.

Length, about 1.34 mm.

Locality.—Off Futagojima, 25 fathoms.

Remarks.—I have secured a single specimen broken at the apertural extremity in the bottom material from Mutsu Bay, and have identified it with *Sigmoidella kagaensis*, a fossil species described by CUSHMAN and OZAWA from Okuwa in Province Kaga, and thus it may be possible that the present species is of both fossil and recent occurrence.

Family **Nonionidae.**

Test typically planispiral, more or less involute; wall calcareous,

finely perforate; aperture simple or cribrate, if simple, at the base of the apertural face.

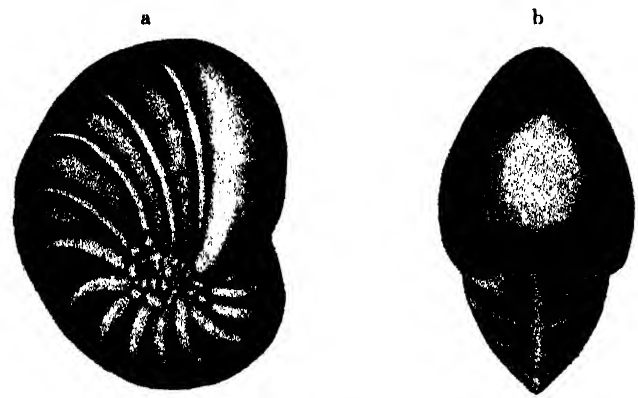
Genus NONION MONTFORT, 1808.

Test free, planispiral, more or less involute, bilaterally symmetrical, periphery broadly rounded to acute; chambers numerous; wall finely perforate; aperture, an arched, usually narrow opening between the base of the apertural face and the preceding coil.

77. Nonion boueana (D'ORBIGNY).
(Text-fig. 76)

Nonionina boueana, H. B. BRADY, 1884, p. 729, pl. 109, figs. 12, 13; EGGER, 1893, p. 234, pl. 19, figs. 34, 35; GOËS, 1894, p. 104, pl. 17, fig. 829; FLINT, 1897, p. 337, pl. 79, fig. 5; MILLETT, 1904, p. 602; CUSHMAN, 1914, p. 28, pl. 16, fig. 1; 1921, p. 366; IKARI, 1927, p. 14, pl. 2, fig. 15a, b; HADA, 1929, p. 14.

Description.—Test oval, compressed, bilaterally symmetrical in apertural view, outer convolution composed of about fifteen narrow, curved visible chambers; umbilical region covered with granular shell



Text-fig. 76. *Nonion boueana* (D'ORBIGNY). ×60.
a, side view. b, peripheral view.

material, from which region wide, limbate, curved sutures radiate; wall smooth, finely perforate; aperture forming a narrow curved slit at the basal margin of the apertural face, often covered with the clear shell material.

Length, up to 0.80 mm.

Localities. — At all stations where collections were made in depths of 4–33 fathoms.

Remarks. — According to the published records we know that the species is common in the waters surrounding Japan. FLINT (1897) reported it from a depth of 9 fathoms in the Gulf of Tokyo, and CUSHMAN (1914) found it in the Albatross material in 37 fathoms off Japan and in the Nero collection in 631 fathoms off Yokohama. IKARI (1927) recorded it from the vicinity of Misaki, and I (1929) have obtained specimens from shallow water off the coast of Hokkaido. It is also commonly found everywhere in Mutsu Bay.

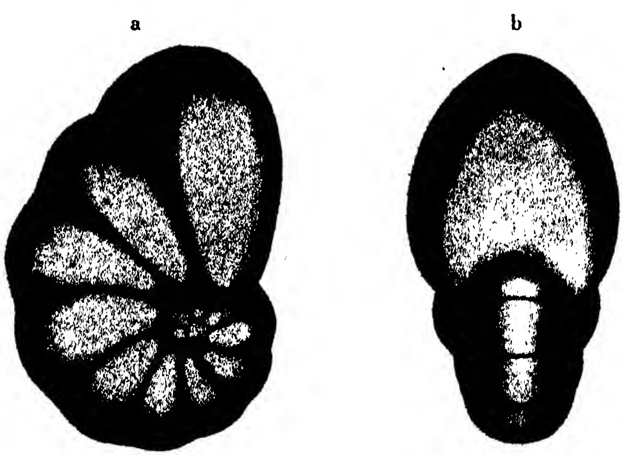
78. Nonion scapha (FICHTEL and MOLL).

(Text-fig. 77)

Nonionina scapha, H. B. BRADY, 1884, p. 730, pl. 109, figs. 14, 15; EGGER, 1893, p. 232, pl. 19, figs. 42, 43; GOËS, 1894, p. 104, pl. 17, fig. 830; 1896, p. 79; FLINT, 1897, p. 337, pl. 80, fig. 1; KIAER, 1900, p. 50; MILLETT, 1904, p. 601; BAGG, 1908, p. 164; SIDEBOTTOM, 1909, p. 13; CUSHMAN, 1914, p. 28, pl. 15, fig. 1, pl. 16, figs. 3, 4; HADA, 1929, p. 14.

Nonion scapha, CUSHMAN, 1927 (a), p. 147.

Description. — Test oval, somewhat compressed, bilaterally symmetrical in apertural view, composed of less than two nautiloid con-



Text-fig. 77. *Nonion scapha* (FICHTEL and MOLL). ×110.
a, side view. b, peripheral view.

volutions, peripheral margin rounded; chambers elongate, increasing rapidly in size as added, about ten chambers forming the outer whorl, apertural face of the last-formed chamber broad, slightly convex; sutures distinct, more or less depressed; surface smooth; aperture in the form of a narrow arched slit at the basal margin of the apertural face.

Length, about 0.45 mm.

Localities. — All stations, 4-33 fathoms.

Remarks. — This species is common in Mutsu Bay. CUSHMAN (1914) recorded it from four Albatross stations, ranging in depth from 84 to 622 fathoms, off Japan. My previous report (1929) was based on the specimens taken from three localities off Hokkaido.

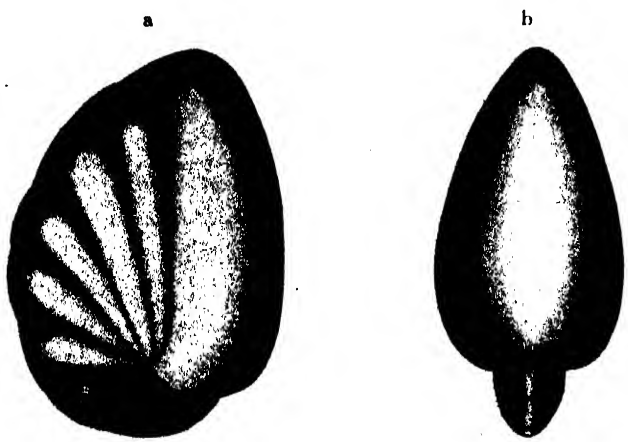
79. Nonion turgida (WILLIAMSON).

(Text-fig. 78)

Rotalina turgida, WILLIAMSON, 1858, p. 50, pl. 4, figs. 95-97.

Nonionina turgida, H. B. BRADY, 1870, p. 306; 1881 (b), p. 17; 1884, p. 731, pl. 109, figs. 17-19; EGGER, 1893, p. 233, pl. 19, figs. 45, 46; GOËS, 1894, p. 105, pl. 17, fig. 832; KIAER, 1900, p. 50; MILLETT, 1904, p. 602; SIDEBOTTOM, 1909, p 13; CUSHMAN, 1914, p. 29, pl. 15, fig. 3.

Description. — Test equilateral, compressed, composed of about ten visible chambers in the outer convolution; chambers elongate, narrow,



Text-fig. 78. *Nonion turgida* (WILLIAMSON). ×80.
a, side view. b, peripheral view.

curved, each becoming longer than its preceding one, last-formed chamber strongly enlarged and widened, often occupying nearly one-half of the whole test, broadest at its base, tapering towards the subacute peripheral margin; sutures distinct, but slightly depressed; wall smooth, thin and somewhat translucent, finely perforate; aperture forming a narrow arched slit, invisible externally.

Length, up to 0.68 mm.

Localities. — It is obtained at all stations, 4–33 fathoms, where the collection were made.

Remarks. — The species is very abundant in the bottom material from Mutsu Bay. Of this species only one previous record in Japanese waters was made by H. B. BRADY (1884) in the Challenger Report, the specimens being secured from *Hyalonema*-ground in 345 fathoms, off the coast of Japan.

Genus NONIONELLA CUSHMAN, 1926.

Test subtrochoid, the dorsal side only partially involute, ventral side completely so, close coiled; chambers especially in the adult inequilateral, the ventral side developing a distinct elongate lobe at the umbilical end, which covers the umbilicus itself; wall calcareous, finely perforate; aperture at the base of the apertural face of the chamber, low and elongate, extending from the peripheral border toward the ventral side.

80. Nonionella pulchella, n. sp.

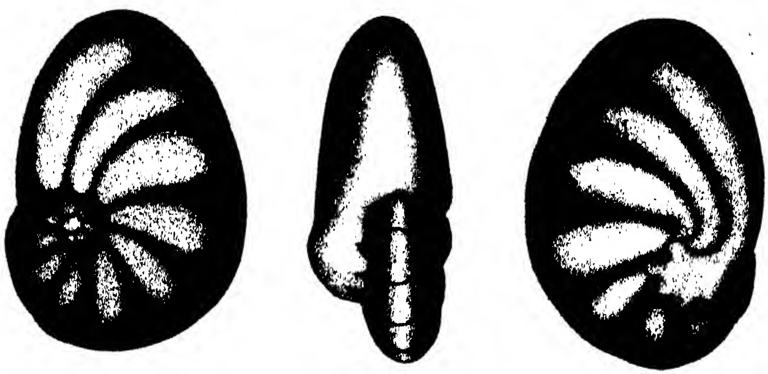
(Text-fig. 79)

Description. — Test oval, compressed, composed of about two convolutions, peripheral margin rounded; chambers narrow, curved, increasing rapidly in size as added, all chambers in the outer whorl visible, umbilical end of the chamber growing in peculiar manner and covering over the umbilicus in the ventral side; sutures distinct, depressed slightly; wall smooth, somewhat translucent or opaque, finely perforate; aperture forming a narrow, arched slit.

Length, about 0.45 mm; breadth, 0.30 mm; thickness, 0.18 mm.

Localities. — All stations, 4–33 fathoms.

Remarks. — This species is found abundantly in the collections



Text-fig. 79. *Nonionella pulchella*, n. sp. ×100.
a, dorsal view. b, ventral view. c, peripheral view.

from Mutsu Bay. It differs from *Nonionella miocenica* in the crenate margin of the umbilical lobe of the chamber, this margin having five distinct lobelet or crenations, and also in the dorso-ventral diameter of the test which is less in this species than in CUSHMAN's (1926, pl. 13, fig. 4 c) *N. miocenica*. In this species occurrences of the different directions of the convolutions building up the test are nearly equall in Mutsu Bay.

Genus ELIPHIDIUM MONTFORT, 1808.

Test typically planispiral, bilaterally symmetrical, mostly involute; chambers numerous with distinct sutures either depressed or raised and limbate, with septal bridge and depressions; wall calcareous, perforate; apertures one or more at the base of the apertural face.

81. Eliphidium striato-punctatum (FICHTEL and MOLL).

(Text-fig. 80)

Polystomella striato-punctata, H. B. BRADY, 1870, p. 305; 1881 (b), p. 18; 1884, p. 733, pl. 109, figs. 22, 23; EGGER, 1893, p. 241, pl. 19, figs. 49, 50; GOËS, 1894, p. 101, pl. 17, figs. 815c, f, k, l, 822; 1896, p. 78; FLINT, 1897, p. 337, pl. 80, fig. 2; KIAER, p. 51; MILLETT, 1904, p. 602; RHUMBLER, 1907, p. 73, pl. 5, figs. 61, 62; CUSHMAN, 1908, p. 31, pl. 5, fig. 4; HERON-ALLEN and EARLAND, 1909, p. 695; SIDEBOTTOM, 1909, p. 14, fig. 10, pl. 5, figs. 1, 2; CUSHMAN, 1914, p. 31, pl. 18, fig. 2; HERON-ALLEN

and EARLAND, 1915, p. 732; HOFKER, 1927, p. 54, pl. 26, figs. 3, 4, 7, pl. 27, figs. 9, 10, pl. 28, fig. 9; HADA, p. 14.

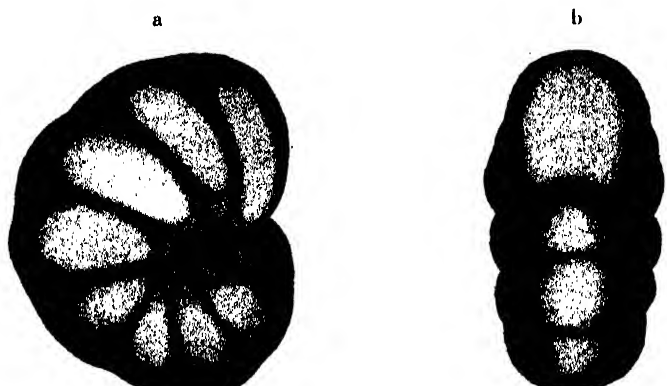
Eliphidium striato-punctatum, CUSHMAN and LEAVITT, 1929, p. 19, pl. 4, figs. 5, 6.

Description. — Test discoidal, equilateral, slightly depressed at the umbilical region often filled with the fine shell material; peripheral margin rounded; about ten inflated chambers forming the last-formed convolution which encloses all predecessors; septal bridges regular, distinct; wall smooth, finely perforate; aperture usually in the form of an arched opening at the basal margin of the apertural face.

Diameter, up to 0.82 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms.

Remarks. — This species is fairly common in Mutsu Bay. From many previous records it may be assumed that several variable forms



Text-fig 80. *Eliphidium striato-punctatum* (FICHTEL and MOLL). ×60. a, side view. b, peripheral view.

are included under this name. Among the species obtained from Mutsu Bay there may be distinguished at least two forms. The first is comparatively large and broad with septal depressions clearly visible, while the second is small with a thin and translucent wall with narrow septal bridges. In the material from the littoral area off Hokkaido I (1929) have obtained specimens equally in size those found in Mutsu Bay.

82. Eliphidium crispum (LINNÉ).

Polymorphina crispa, WILLIAMSON, 1858, p. 40, pl. 3, figs. 78, 79; CARPENTER, PARKER and JONES, 1862, p. 278, pl. 16, figs. 4–6; H. B. BRADY, 1884, p. 736, pl. 110, figs. 6, 7; EGGER, 1893, p. 240, pl. 20, figs. 20, 21; GOËS, 1894, p. 102, pl. 17, figs. 820, 821; CHAPMAN, 1895, p. 45; FLINT, 1897, p. 338, pl. 80, fig. 3; KIAER, 1900, p. 51; MILLETT, 1904, p. 603, pl. 11, fig. 2; CUSHMAN, 1908, p. 32; SIDEBOTTOM, 1909, p. 15; CUSHMAN, 1914, p. 32, pl. 18, fig. 1; 1921, p. 368; HERON-ALLEN and EARLAND, 1924, p. 640; CUSHMAN, 1925 (a), p. 136; IKARI, 1927, p. 15, pl. 2, figs. 16a, b; HOFKER, 1927, p. 55, pl. 26, fig. 8, pl. 27, figs. 5, 6, 11, 12, pl. 28, 3, 5–7; HADA, 1929, p. 14.

Eliphidium crispum, CUSHMAN and LEAVITT, 1929, p. 20, pl. 4, figs. 3, 4.

Descripton.—Test thick, lenticular, both faces convex, peripheral margin keeled with the sharp edge, composed of numerous, long, narrow, curved chambers with the final visible convolution enclosing all the predecessors; umbilical portion umbonate, convex, filled with a mass of clear shell substance and provided with a few small depressions; septal depressions large; aperture consisting usually of pores arranged in a V-shaped line at the basal margin of the apertural face.

Diameter, about 0.95 mm.

Localities.—Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

Remarks.—I have found a few specimens in the collections from Mutsu Bay. Previous records of this species from Japanese waters are three; the first of CUSHMAN (1914) from the "Nero" material in 613 fathoms off Japan, the second of IKARI (1927) from Misaki and the third of mine (1929) from the littoral area off Hokkaido.

83. Eliphidium subnodosum (MÜNSTER).

(Text-fig. 81)

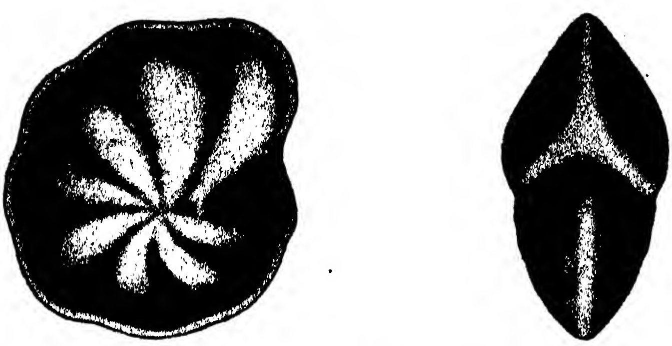
Polystomella subnodosa, H. B. BRADY, 1844, p. 734, pl. 110, fig. 1a, b; GOËS, 1894, p. 102, pl. 17, figs. 817–819; KIAER, 1900, p. 51; MILLETT, 1904, p. 604; BAGG, 1908, p. 165; SIDEBOTTOM, 1909, p. 16, pl. 5, fig. 6; CUSHMAN, 1914, p. 32, pl. 14, fig. 8; 1921, p. 367.

Description.—Test lenticular, symmetrical, both sides convex, peripheral margin subacute, carinate; umbilical area usually umbonate; ten or more chambers forming the outer visible convolution enclosing all others; septal lines curved, scarcely depressed, with distinct septal

depressions; surface smooth, polished; aperture an arched slit at the basal margin of the apertural face.

Diameter, about 0.60 mm.

Localities. — At all stations, in 4-33 fathoms, where collections were made.



Text-fig. 81. *Eliphidium subnodosum* (MÜNSTER). ×70.
a, side view. b, peripheral view.

Remarks. — The species is not very common in Mutsu Bay, but was secured in every collection examined. CUSHMAN (1914) obtained the specimens from the Inland Sea of Japan and from the eastern channel of the Korea Strait.

84. Eliphidium macellum (FICHTEL and MOLL).

Polystomella macella, H. B. BRADY, 1884, p. 737, pl. 110, figs. 8, 9, 11; EGGER, 1893, p. 240, pl. 20, figs. 22, 23; BAGG, 1908, p. 165; SIDEBOTTOM, 1909, p. 15, pl. 5, fig. 4; CUSHMAN, 1914, p. 33, pl. 18, fig. 3; 1920 (b), p. 633; 1922 (b), p. 56, pl. 10, figs. 1, 2; HERON-ALLEN and EARLAND, 1924, p. 640; HADA, 1929, p. 14.

Polystomella crispa, HOFKER, 1927, p. 55, pl. 26, figs. 5, 6, 9, pl. 27, figs. 7, 8, pl. 28, figs. 1, 2.

Eliphidium macellum, CUSHMAN and LEAVITT, 1929, p. 18, pl. 4, figs. 1, 2.

Description. — Test discoidal, compressed, bilaterally symmetrical, composed of numerous, long, curved chambers in the visible, last-formed convolution; periphery keeled sharply; umbilical region slightly depressed, usually porous, occasionally filled with clear shell material; surface marked with the well-definited reticular work; aperture formed

of small openings arranged in a curved row at the basal margin of the apertural face.

Diameter, about 0.75 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

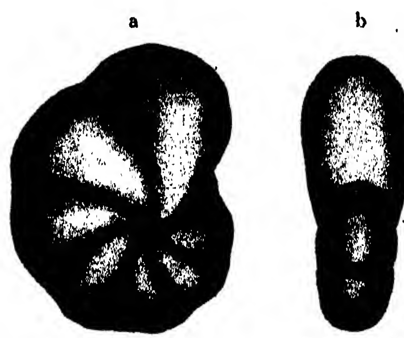
Remarks. — This species is commonly found in the collections from Mutsu Bay, being represented by specimens of two types which are more or less different from each other as in H. B. BRADY (1884, pl. 110, figs. 8, 9). CUSHMAN (1914) recorded this species from the Gulf of Tokyo, in 9 fathoms and from the Albatross stations, in 120 fathoms and in 500 fathoms off Japan. I (1929) have previously found it in the shallow water off Oshoro and Nemuro in Hokkaido.

85. Eliphidium fabum (FICHTEL and MOLL).

(Text-fig. 82)

Polystomella faba, HERON-ALLEN and EARLAND, 1916 (a), p. 281, pl. 43, figs. 11–19; HADA, 1929, p. 14.

Description. — Test compressed, bilaterally symmetrical, composed of about eight visible chambers in the outer convolution embracing other predecessors; chambers rather broad, somewhat inflated; peripheral margin rounded; umbilical region slightly depressed, covered with fine granular shell material; septal depressions and septal bridges marked rather indistinctly due to sutural depressions filled with the fine granular material; wall finely perforate; aperture in the form of an arched slit at the basal margin of the apertural face.



Text-fig. 82. *Eliphidium fabum* (FICHTEL and MOLL). ×80.
a, side view. b, peripheral view.

Diameter, about 0.48 mm.

Localities. — Off Yunoshima, 18 fathoms; between Ōshima and Bentenjima, 33 fathoms.

Remarks. — This is a comparatively rare species in Mutsu Bay.

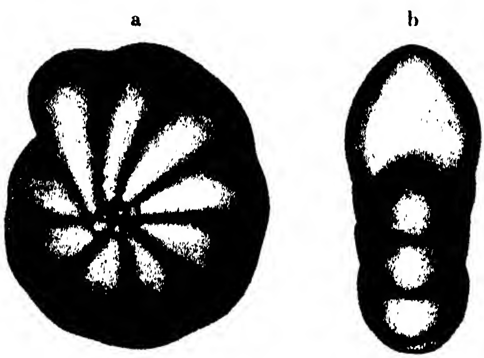
Previously I (1929) have secured the species from shallow water off Hokkaido.

86. Eliphidium decipiens (COSTA).

(Text-fig. 83)

Polystomella decipiens, HERON-ALLEN and EARLAND, 1916 (a), p. 282, pl. 43, figs. 20–22; HADA, 1929, p. 14.

Description. — Test discoidal, bilaterally symmetrical, compressed, outer whorl composed of about ten somewhat inflated, visible chambers, enclosing entirely all preceding ones; peripheral margin rounded, umbilical region roughly granulated, depressed slightly; septal depressions distinct in the later sutures, while indistinct and forming long irregular grooves in the earlier visible sutures; wall more or less translucent, finely perforate; basal margin of the apertural face of the last-formed chamber slightly crenulate externally, with a narrow, curved, slit-like aperture; color usually white, sometimes yellowish brown.



Text-fig. 83. *Eliphidium decipiens* (COSTA). ×80. a, side view. b, peripheral view.

Diameter, about 0.54 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms; between Ōshima and Bentenjima, 33 fathoms.

Remarks. — Judging from the examination of the specimens obtained in Mutsu Bay and in shallow water off Hokkaido (1929), this species seems to be widely distributed in the shallow water surrounding the northern part of Japan.

Family Buliminidae.

Test typically an elongate spiral, divided into chambers, in the specialized genera biserial, or uniserial, or even monothalamous; wall

calcareous, perforate; aperture loop-like or rounded and terminal, usually with some sort of apertural tooth or spiral connected with the interior tubular siphons connecting the apertures.

Subfamily BULIMININAE.

Test spiral, usually triserial, becoming involute and finally in *Entosolenia* monothalamous; aperture loop-shaped, the larger end away from the inner margin, (or in *Entosolenia* rounded) usually with a distinct tooth and internal tube connecting the chambers, (or in *Entosolenia* free at the inner end).

Genus BULIMINA D'ORBIGNY, 1826.

Test, an elongate spiral, generally triserial; chambers inflated, spiral suture more or less obsolete; wall calcareous, perforate; aperture loop-shaped with a tooth or plate at one side and an internal spiral tube connecting through the chambers between the apertures.

87. Bulimina aculeata D'ORBIGNY.

(Text-fig. 84)

Bulimina pupoides, var. *spinulosa*, WILLIAMSON, 1858, p. 62, pl. 5, fig. 128.

Bulimina aculeata, H. B. BRADY, 1884, p. 406, pl. 51, figs 7–9; EGGER, 1893, p. 95, pl. 8, figs. 72, 78; CHAPMAN, 1895, p. 22; GOËS, 1896, p. 45; FLINT, 1897, p. 291, pl. 37, fig. 4; MILLETT, 1900, p. 278; SIDEBOTTOM, 1905, p. 12; BAGG, 1908, p. 134; HERON-ALLEN and EARLAND, 1908, p. 332; CUSHMAN, 1911, p. 86, text-fig. 139a, b; HERON-ALLEN and EARLAND, 1913 (c), p. 63; PEARCEY, 1914, p. 1014; HERON-ALLEN and EARLAND, 1916 (a), p. 236; 1916 (b), p. 42; CUSHMAN, 1921, p. 161, pl. 31, fig. 5; 1922 (a), p. 96, pl. 22, figs. 1, 2.

Description. — Test ovate, composed of inflated chambers arranged triserially and more or less overlapping the predecessors, early portion provided with many long spines, later portion smooth, but lower margin of the later chambers crenulate or with short spines; sutures distinct, much depressed; wall in the adult opaque; aperture fairly broad, loop-shaped.

Length, about 0.38 mm.

Localities. — Off Yunoshima, 18 fathoms; off Futagojima, 17–25 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This species is comparatively rare in Mutsu Bay, and in the material obtained from this bay I have found a number of

Text-fig. 84. *Bulimina aculeata* D'ORBIGNY. ×120.
a, side view. b, apertural view.

specimens with comparatively short spines. H. B. BRADY (1884) reported this species from a single Challenger station, 345 fathoms deep, on the *Hyalonema*-ground south of Japan and CUSHMAN (1911) obtained it also from a great number of stations in the Western Pacific about Japan, ranging in depth from 76 to 1299 fathoms.

Genus ENTOSOLENIA EHRENBERG, 1848.

Test monothalamous, the single chamber with an internal tube free at the inner end; wall usually thin, finely perforate; aperture elliptical or circular.

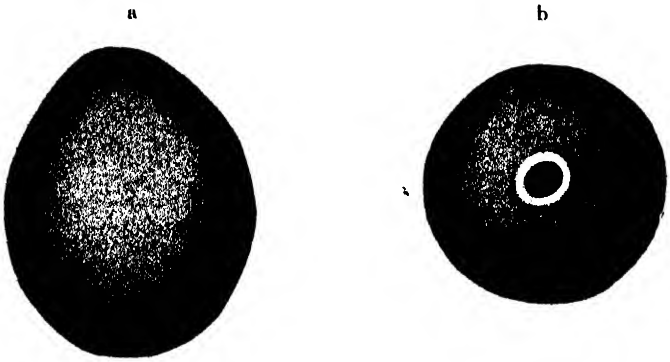
88. Entosolenia globosa (MONTAGU).
(Text-fig. 85)

Entosolenia globosa, WILLIAMSON, 1848, p. 16, pl. 2, figs. 13, 14; 1858, p. 8, pl. 1, figs. 15, 16.

Lagena globosa, H. B. BRADY, 1870, p. 293; BUTSCHLI, 1880–1882, p. 197, pl. 7, fig. 2; H. B. BRADY, 1881 (b), p. 13; 1884, p. 452, pl. 56, figs. 1–3; EGGER, 1893, p. 131, pl. 10, fig. 69; CHAPMAN, 1895, p. 27; FLINT, 1897, p. 306, pl. 53, fig. 4; KIAER, 1900, p. 39; MILLETT, 1901, p. 3; SIDEBOTTOM, 1906, p. 1; RHUMBLER, 1907, p. 63; BAGG, 1908, p. 141; HERON-ALLEN

and EARLAND, 1909, p. 422; 1913 (c), p. 72; CUSHMAM, 1914, p. 3, pl. 4, fig. 2; HERON-ALLEN and EARLAND, 1915, p. 654; 1916 (a), p. 242; 1916 (b), p. 44; CUSHMAN, 1920 (b), p. 607; 1921, p. 173; 1923, p. 20, pl. 4, figs. 1, 2; HADA, 1929, p. 12.

Description. — Test globular, smooth, circular in transverse section, slightly drawn out at the apertural end; wall usually translucent, some-



Text-fig. 85. *Entosolenia globosa* (MONTAGU). ×140.
a, front view. b, apertural view.

times opaque; aperture opening at the central portion of the apertural end, connecting with an internal tube.

Length, about 0.30 mm.

Locality. — Off Yunoshima, 18 fathoms.

Remarks. — This species is very rare in Mutsu Bay, and I have found only one small specimen in the collections obtained from that bay. I (1929) have secured a few specimens of this species from Oshoro Inlet, Hokkaido.

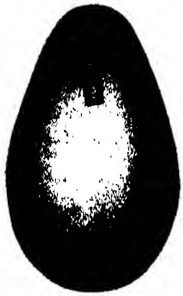
89. Entosolenia lucida WILLIAMSON.

(Text-fig. 86)

Entosolenia marginata*, var. *lucida, WILLIAMSON, 1848, p. 17, pl. 2, fig. 17.

Lagena lucida, KIAER, 1900, p. 40; MILLETT, 1901, p. 494; SIDEBOTTOM, 1906, p. 6, pl. 1, figs. 9–12; HERON-ALLEN and EARLAND, 1909, p. 425; CUSHMAN, 1913, p. 36; 1913 (c), p. 87; 1916 (a), p. 249; 1916 (b), p. 46; CUSHMAN, 1923, p. 33, pl. 6, figs. 1, 2; HADA, 1929, p. 12.

Description. — Test elongate, elliptical in side view, slightly compressed, surrounded by faint marginal carina becoming more distinct



Text-fig. 86. *Entosolenia lucida* (WILLIAMSON). ×150.

at both ends; apertural end somewhat produced, basal end usually rounded, occasionally tapering into the apiculate end; wall smooth, translucent; aperture usually slit-like, connecting with an internal tube.

Length, about 0.25 mm.

Localities. — Off Yunoshima, 18 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This species is somewhat common at depths greater than 18 fathoms in Mutsu Bay. The apiculate form is very rare as compared with typical form; only one apiculate form being found among about ten specimens. In the neighbouring seas about Japan CUSHMAN (1913) reported the species from two stations and I (1929) have seen this form in the material from shallow water off Hokkaido.

Subfamily VIRGULININAE.

Test usually showing traces of its spiral origin in the twisted young, later biserial, and in the end forms uniserial.

Genus VIRGULINA D'ORBIGNY, 1826.

Test elongate, more or less compressed fusiform, the early chambers spiral about the elongate axis, triserial, later ones becoming irregularly biserial, whole test usually twisted; wall calcareous, finely perforate; aperture elongate, loop-shaped, usually with an apertural tooth or plate and internal tube.

90. **Virgulina schreibersiana** CZJZEK.

(Text-fig. 87)

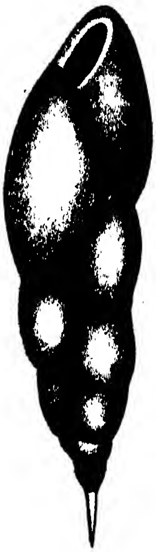
Virgulina schreibersiana, H. B. BRADY, 1881 (b), p. 13; 1884, p. 414, pl. 52, figs. 1–3; EGGER, 1893, p. 98, pl. 8, figs. 93, 95; GOËS, 1894, p. 48, pl. 9, figs. 459, 461–472; CHAPMAN, 1895, p. 23; FLINT, 1897, p. 291, pl. 37, fig. 6; KIAER, 1900, p. 34; SIDEBOTTOM, 1905, p. 13, pl. 3, fig. 4; CUSHMAN, 1911, p. 94, text-fig. 148a, b; 1921, p. 169; 1922 (a), p. 117, pl. 26, fig. 6; 1927 (a), p. 153, pl. 3, fig. 3; CUSHMAN and WICKENDEN, 1929, p. 9, pl. 4, fig. 2a, b.

Description. — Test elongate, conical, somewhat compressed, slightly curved, tapering gradually to the apical end with a spine; chambers more less long, inflated, generally arranged biserially; sutures distinct, depressed; wall somewhat translucent; surface smooth, polished; aperture elongate, oval, loop-shaped.

Length, about 0.45 mm.

Locality. — Off Futagojima, 25 fathoms.

Remarks. — Rare, only two specimens found in the collections from Mutsu Bay.



Text-fig. 87. *Virgulina schreibersiana* CZJZEK. × 150.

Genus BOLIVINA D'ORBIGNY, 1839.

Test elongate, usually somewhat compressed, tapering from the subacute or rounded initial end, which is often twisted; chambers typically biserial; wall calcareous, perforate; aperture elongate, usually oblique to the median plane, elongate, reaching to the base of the chamber, often with a plate-like tooth connecting with an internal tube.

91. Bolivina robusta H. B. BRADY.

(Text-fig. 88)

Bolivina robusta, H. B. BRADY, 1881 (a), p. 57; 1884, p. 421, pl. 53, figs. 7-9; EGGER, 1893, p. 102, pl. 8, figs. 31, 32; CHAPMAN, 1895, p. 24; CUSHMAN, 1911, p. 36, text-figs. 59, 60; 1921, p. 129; HADA, 1929, p. 11.

Description. — Test elongate, compressed, tapering gradually and slightly to the initial end, at which sometimes apiculate, thickest on the long median line of the test, slightly thining out to the lateral subacute edges somewhat carinate; chambers long, narrow, curved slightly, arranged biserially, eight to ten in each row, crenulate on the lower margin of each chamber; sutures distinct, somewhat limbate; wall rather coarsely perforate; aperture elongate, situated obliquely.

Length, about 0.50 mm.

Locality. — Off Yunoshima, 18 fathoms.

Remarks. — The species is rare in Mutsu Bay, and no apiculate

form was in the material. CUSHMAN (1911) has detected this species in the collections obtained at many Nero and Albatross stations off the southern coast of Japan, and I (1929) have collected the specimens from Oshoro Inlet and Akkeshi Bay in Hokkaido.

Text-fig. 88. *Bolivina robusta* H. B. BRADY. ×120.
a, side view.
b, apertural view.

Text-fig. 89. *Bolivina seminuda* CUSHMAN. ×85.
a, side view.
b, apertural view.

92. Bolivina seminuda CUSHMAN.

(Text-fig. 89)

Bolivina seminuda, CUSHMAN, 1911, p. 34, text-fig. 55; 1927 (a), p. 157, pl. 3, fig. 6; HADA, 1929, p. 11.

Description.—Test elongate, somewhat compressed, tapering slightly towards the aboral end bluntly pointed, obliquely truncate at the oral region; peripheral margin rounded; chambers arranged biserially, more or less inflated; sutures distinct; wall thin and hyaline, the proximal area of each chamber rather coarsely perforate, the distal area smooth,

without perforation; aperture elongate, loop-like, placed obliquely on the apertural face; color white or yellowish white.

Length, about 0.60 mm.

Localities. — Off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms.

Remarks. — In the collections taken from Mutsu Bay the species is frequently found. It was rather rare in the collection from Oshoro Inlet.

Subfamily REUSSIINAE.

Test distinctly triserial, at least in the young of most forms, in specialized forms becoming uniserial; aperture in the simpler forms and in the young, elongate, in the uniserial forms and some of the triserial ones, cribrate.

Genus REUSSIA SCHWAGER, 1877.

Test distinctly triserial, triangular in transverse section, broadest at the apertural end; wall calcareous, perforate; aperture elongate, oblique, in the triangluar apertural face.

93. **Reussia spinulosa** (REUSS).
(Text-fig. 90)

Verneuilina spinulosa, H. B. BRADY, 1884, p. 384, pl. 47, figs. 1–3; EGGER, 1893, p. 89, pl. 7, figs. 11, 14–16; MILLETT, 1900, p. 11; SIDEBOTTOM, 1905, p. 10, pl. 2, fig. 5; RHUMBLER, 1907, p. 61, pl. 5, fig. 53; BAGG, 1908, p. 132; HERON-ALLEN and EARLAND, 1908, p. 327; CUSHMAN, 1911, p. 55, text-fig. 88a, b; PEARCEY, 1914, p 1039; CUSHMAN, 1921, p. 141, pl. 27, fig. 5; 1922 (a), p. 60, pl, 19, fig. 5; 1922 (b), p. 28, pl. 3, fig. 11; 1922 (c), p. 51; 1925 (a), p. 125; 1926 (a), p. 76; IKARI, 1927, p. 11, pl. 1, fig. 8; HADA, 1929, p. 11.

Text-fig. 90. *Reussina spinulosa* (REUSS). ×110.

Description. — Test tricarinate, triangular in transverse section, tapering towards the initial end with a tapering

terminal spine ; chambers numerous, arranged triserially, each terminating in an angle with a spine and with edges thickened ; wall smooth, translucent, often provided with a number of short spines distributed irregularly ; aperture elongate at the triangular apertural face.

Length without the spine, about 0.50 mm.

Localities. — Off Yunoshima, 10–18 fathoms ; off Futagojima, 23 fathoms ; near Ōshima, 23 fathoms.

Remarks. — This species is not very common in Mutsu Bay. According to the records previously published this species seems to be widely distributed especially in comparatively shallow waters CUSHMAN (1911) detected the specimens in the material from many stations distributed among the waters off Japan. IKARI (1927) found it in the bottom sand from Misaki, and I (1929) have secured the specimens from Oshoro Inlet, Hokkaido.

Subfamily UVIGERININAE.

Test generally triserial, at least in the early stages, later in some forms uniserial or irregular ; aperture typically terminal with a neck and hyaline lip, and in some genera a spiral tooth and an internal twisted tube connecting the chambers.

Genus SIPHOGENERINA SCHLUMBERGER, 1883.

Test elongate, cylindrical, with the early stages typically triserial, rounded in section, later uniserial ; wall calcareous, perforate ; aperture in the adult terminal, with a distinct neck, hyaline lip and internal tube.

94. **Siphogenerina raphanus** (PARKER and JONES).
(Text-fig. 91)

Sagrina raphanus, H. B. BRADY, 1884, p. 585, pl. 75, figs. 21–24 ; MILLETT, 1903, p. 272 ; HERON-ALLEN and EARLAND, 1915, p. 677.

Siphogenerina raphanus, EGGER, 1893, p. 125, pl. 9, fig. 36 ; CUSHMAN, 1913, p. 108, pl. 46, figs. 1–5 ; 1921, p. 280, pl. 56, fig. 7 ; 1922 (b), p. 35, pl. 5, fig. 5 ; 1923, p. 175, pl. 42, fig. 14 ; 1924 (b), p. 28, pl. 8, figs. 1, 2 ; 1925 (a), p. 128 ; 1926 (b), p. 4, pl. 1, figs. 1–4, pl. 2, figs. 1–3, 10, pl. 5, figs. 1, 2 ; IKARI, 1927, p. 13, pl. 2, fig. 5a, b ; HADA, 1929, p. 13.

Description. — Test either cylindrical or somewhat tapering; chambers broader than long in the straight uniserial portion; sutures somewhat depressed; surface marked with raised ridges running along nearly entire length of the test; aperture comparatively large, circular, opening at the end of a short neck, with a well-developed lip.

Length, up to 1.70 mm.

Localities. — Off Yunoshima, 18 fathoms; off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms.

Remarks. — This species occurs frequently in Mutsu Bay. The records given by CUSHMAN (1913), IKARI (1927) and myself (1929) tell us that this species is widely distributed in the waters off Japan. The megalospheric and microspheric forms of this species may be distinguished by the external shape of the test. In the megalospheric form the test is usually rounded at the initial end, while in the microspheric one it is bluntly pointed at that end.

Text-fig. 91. *Siphogenerina raphanus* (PARKER and JONES). ×40.
a, side view.
b, apertural view.

Family **Rotaliidae.**

Test generally trochoid except in *Spirillina*, all the chambers visible from the dorsal side except in a very few genera which become partially involute, only those of the last-formed whorl usually visible from the ventral side; wall calcareous, usually rather coarsely perforate; aperture typically on the ventral side of the test.

Subfamily ROTALIINAE.

Test trochoid, umbilical region typically closed, sometimes with a definite conical plug of clear shell material; wall of the test often double and a tubular canal system developed; apertural ventral, along the margin of the chamber between the periphery and the umbilical area.

Genus ROTALIA LAMARCK, 1804.

Test trochoid, usually biconvex, the umbilical area closed, usually having a conical plug of clear shell material; sutures on the ventral side usually deeply depressed and often ornamented along the sides, dorsal side usually limbate; wall calcareous, perforate, often double; aperture, an arched opening at the border of the ventral face midway between the periphery and the umbilical area, interseptal canal sometimes present.

95. **Rotalia papillosa** H. B. BRADY.

Rotalia papillosa, H. B. BRADY, 1884, p. 708, pl. 106, fig. 9a–c; FLINT, 1897, p. 332, pl. 76, fig. 2; MILLETT, 1904, p. 505; CUSHMAN, 1915, p. 70, pl. 31, fig. 1; 1921, p. 347, pl. 72, fig. 3a, b; IKARI, 1927, p. 14, pl. 2, fig. 3a–c.

Description. — Test subglobular, hightly convex on both sides, peripheral margin rounded, composed of three or more convolutions with the last-formed whorl consisting of ten to thirteen chambers; sutures externally variable in shape and character, irregularly limbate on the dorsal side; umbilical region covered with granular shell material as well as sutures on the ventral side; aperture, an arched fissure at the inner margin of the apertural face on the ventral side.

Diameter, up to 1.80 mm.

Localities. — Near the Marine Biological Station, 4–10 fathoms; off Yunoshima, 10–18 fathoms; off Futagojima, 17–25 fathoms; near Ōshima, 23 fathoms.

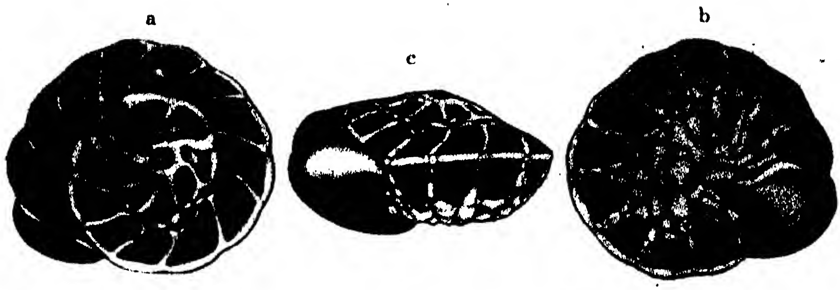
Remarks. — This species occurs very frequently in the comparatively shallow area of Mutsu Bay. CUSHMAN (1915) previously reported it from the eastern channel of the Korea Strait, and IKARI (1927) recorded it from Misaki.

96. **Rotalia papillosa** H. B. BRADY, var. **compressiuscula** H. B. BRADY.

(Text-fig. 92)

Rotalia papillosa, var. *compressiuscula*, H. B. BRADY, 1884, p. 708, pl. 107, fig. 1a–c, pl. 108, fig. 1a–c; CUSHMAH, 1915, p. 70, pl. 30, fig. 1; 1921, p. 348, pl. 72, fig. 2a–c.

Description. — This variety differs from the typical species in the



Text-fig. 92. *Rotalia papillosa* H. B. BRADY, var. *compressiuscula* H. B. BRADY. ×20.

a, dorsal view. b, ventral view. c, side view.

compressed form with the subacute peripheral margin.

Localities. — Near the Marine Bilological Station, 4-10 fathoms; off Yunoshima, 10-18 fathoms; off Futagojima, 17-25 fathoms.

Remarks. — This variety is usually found in company with the typical form in the material obtained from Mutsu Bay, and the distinctions between them is not very clear. This variety was previously reported by H. B. BRADY (1884) from the Inland Sea of Japan and by CUSHMAN (1915) from the eastern channel of the Korea Strait where the typical form of this species was also secured.

97. **Rotalia japonica**, n. sp.

(Text-fig. 93)

Description. — Test subglobular, biconvex, ventral side more convex, composed of about four convolutions, of which the last-formed coil consists of from eight to ten chambers, peripheral margin rounded; sutures on the dorsal side nearly straight, those of the central portion not so deep as in the peripheral part, same of the outer coils depressed, ventral side marked by deep sutural depressions; umbilical area usually slightly depressed, granulated, covered with a plug of clear shell material; wall rather smooth, sometimes polished on the dorsal side; aperture in the form of a narrow slit at the inner margin of the apertural face on the ventral side; color usually yellowish or greyish brown in the central portion of the dorsal surface, fading gradually towards the outer coil.

Diameter, up to 0.90 mm; thickness up to 0.50 mm.

Localities. — Off the Marine Biological Station, 5–18 fathoms; off Futagojima, 17–25 fathoms; between Ōshima and Bentenjima, 30–33 fathoms.

Remarks. — This species is abundant in Mutsu Bay, and occurs also in the shallow water of the Pacific coast of Hokkaido. This

Text-fig. 93. *Rotalia japonica*, n. sp. × 40.
a, dorsal view. b, ventral view. c, side view.

seems to be allied to *Rotalia beccarii*, but it differs from the latter in thickness of the test and in the radiating straight sutural lines on the dorsal side. This species also resembles the specimen figured by H. B. BRADY (1884), pl. 107, fig. 5) as *Rotalia orbicularis* (?) D'ORBIGNY in the Challenger Report.

Subfamily BAGGININAE.

Test generally biconvex, the umbilical area closed, the area adjacent to it on each chamber with a thinner, rounded, clear area, usually without perforations; aperture at the base of the ventral margin of the chamber.

Genus CANCRIS MONTFORT, 1808.

Test trochoid, nearly equally biconvex, compressed; chambers few, rapidly enlarging as added; wall calcareous, perforate; umbilical area with a clear plate of rather large dimensions for the size of the test; aperture narrow, on the inner border of the ventral side of the last-formed chamber.

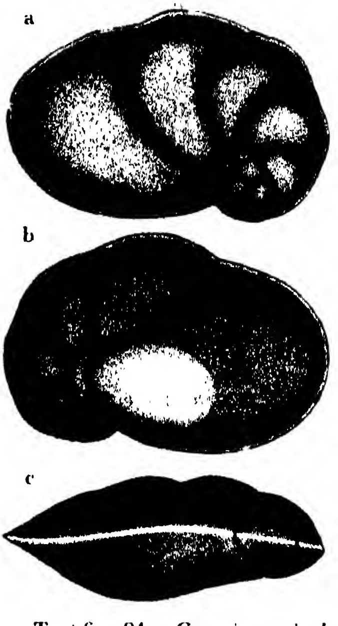
98. Cancris auricula (FICHTEL and MOLL).
(Text-fig. 94)

Pulvinulina auricula, H. B. BRADY, 1884, p. 688, pl. 106, fig. 5a–c; EGGER, 1893, p. 223, pl. 17, figs. 26–28; GOËS, 1894, p. 98, pl. 16, figs. 809, 810; 1896, p. 77; FLINT, 1897, p 329, pl. 73, fig. 2; KIAER, p. 47; CUSHMAN, 1915, p. 55, pl. 22, fig. 1; 1920 (b), p. 631; 1921, p. 329, pl. 69, figs. 3a–c; 1927 (a), p. 164, pl. 5, fig. 10.

Description. — Test oblong, trochoid, nearly equally biconvex, compressed, peripheral margins acute, somewhat carinate; chambers more or less inflated, increasing rapidly in size as added, six to eight chambers forming the outer convolution, last-formed chamber occupying more than half the ventral surface; sutures distinct, slightly depressed, curved strongly; wall rather thin, somewhat hyaline, finely and distinctly perforate except in the rounded area at the umbilical end of each chamber on the ventral side; aperture in the form of an arched slit on the inner border of the last-formed chamber on the ventral side.

Length, about 0.65 mm.

Localities. — Off Yunoshima, 18 fathoms; off Futagojima, 20–25 fathoms.



Text-fig. 94. *Cancris auricula* (FICHTEL and MOLL). ×65. a, dorsal view. b, ventral view. c, peripheral view.

Remarks. — This species seems to be rather rare in Mutsu Bay, only several specimens being secured.

Family Globigerinidae.

Test, at least in the early stages, trochoid, umbilicate; wall calcareous, rather coarsely perforate, usually with a cancellated surface, in well preserved specimens of the simpler genera with fine spines; aperture typically large but in the higher genera consisting of numerous small openings variously placed.

Subfamily GLOBIGERININAE.

Wall clothed with fine spines, typically trochoid but in some genera becoming planispiral; wall often cancellated, coarsely perforate.

Genus GLOBIGERINA D'ORBIGNY, 1826.

Test trochoid throughout, umbilicate, chambers in the young especially of the microspheric form in a flattened trochoid form like *Discorbis* usually smooth and the wall thin, later chambers globular; wall thick and cancellated, in well preserved, especially in pelagic specimens, clothed with long slender spines coming from the angles of the cancellated surface areas, the base of such areas with the pores of the wall, calcareous; aperture large, opening into the umbilicus.

99. Globigerina bulloides D'ORBIGNY.

Globigerina bulloides, PARKER and JONES, 1857, p. 291, pl. 11, figs. 11, 12; WILLIAMSON, 1858, p. 56, pl. 5, figs. 116-118; H. B. BRADY, 1870, p. 298; 1879, p. 28; 1881 (b), p. 15; GOËS, 1882, p. 90, pl. 6, figs. 165-207; H B. BRADY, 1884, p. 593, pl. 77, pl. 79, figs. 3-7; EGGER, 1893, p. 170, pl. 13, figs. 1-4; GOËS, 1894, p. 83, pl. 44, figs. 751-760; CHAPMAN, 1895, p. 26; GOËS, 1896, p. 65; FLINT, 1897, p. 321, pl. 69, fig. 2; KIAER, 1900, p. 48; RHUMBLER, 1900, p. 21, text-figs. 24-26; MILLETT, 1903, p. 685; BAGG, 1908, p. 153; SIDEBOTTOM, 1908, p. 3; CUSHMAN, 1814, p. 5, pl. 2, figs. 7-9, pl. 9; 1920 (b), p. 621; 1921, p. 285; 1922 (b), p. 35; 1922 (c), p. 54, pl. 12, fig. 5; 1924 (a), p. 7, pl. 2, figs. 1-4; HERON-ALLEN and EARLAND, 1924, p. 624; CUSHMAN, 1925 (a), p. 128; 1927 (a), p. 171; HADA, 1929, p. 13.

Description. — Test subglobular, composed of several globose chambers arranged in a trochoid manner, all chambers visible from above, three or four in the last-formed whorl visible from below; sutures remarkably deep; wall rather coarsely perforate; surface reticulate, provided with numerous long projecting spines; aperture large, opening into the umbilical depression.

Diameter, about 0.40 mm.

Localities. — Off Yunoshima; off Futagojima; between Oshima and Bentenjima.

Remarks. — This species is the single pelagic species that I have found in the material from the plankton and also in the bottom collections from Mutsu Bay, where it is not so common. This species

is abundant and cosmopolitan in the open seas of the Pacific Ocean, thus H. B. BRADY (1884) and CUSHMAN (1914) have obtained specimens at everywhere in the waters near the coast of Japan. I (1929) have also obtained dead specimens in the bottom material from Akkeshi Bay, and have the living specimens in the plankton from off Oshoro, Hokkaido.

Family **Anomalinidae.**

Test free, or attached by the dorsal surface which is typically flattened or concave; chambers arranged in a trochoid manner, at least in the early stages, only those of the last-formed chamber visible from the ventral side; wall calcareous, coarsely perforate; aperture in the adult either at the periphery or with an extension on the dorsal side.

Subfamily CIBICIDINAE.

Test with the dorsal side flattened or concave, the aperture extending over into the dorsal side along the inner margin of the chamber or entirely on the dorsal side, test typically attached by the dorsal side to some substrates.

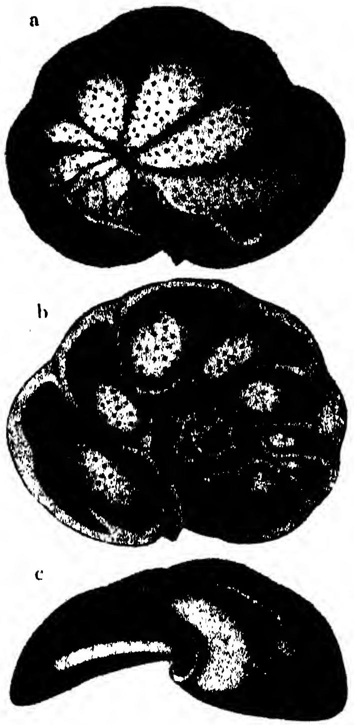
Genus CIBICIDES MONTFORT, 1808.

Test plano-convex, usually attached to various objects by the flattened dorsal side, trochoid; wall calcareous, coarsely perforate; aperture peripheral, at the base of the chamber, sometimes extending ventrally, but typically with a long slit-like extension between the inner margin of the chamber on the dorsal side and the previous whorl nearly or fully the length of the chamber.

100. **Cibicides lobatulus** (WALKER and JACOB).

(Text-fig. 95)

Truncatulina lobatula, WILLIAMSON, 1858, p. 59, pl. 5, figs. 121–123; H. B. BRADY, 1870, p. 303; 1881 (b), p. 17; 1884, p. 660, pl. 92, fig. 10, pl. 93, fig. 1a–c; EGGER, 1893, p. 204, pl. 16, figs. 1–3; CHAPMAN, 1895, p. 4; FLINT, 1897, p. 333, pl. 76, fig. 4; KIAER, 1900, p. 46; CUSHMAN, 1908, p. 30; 1915, p. 31, text-fig. 34, pl. 15, fig. 1; 1920 (b), p. 627; 1921, p. 318, pl. 63, fig. 2a–c; HERON-ALLEN and EARLAND, 1924, p. 635; CUSHMAN, 1925 (a), p. 132; HADA, 1929, p. 13.



Text-fig. 95. *Cibicides lobatulus* (WALKER and JACOB). ×40.
a, dorsal view. b, ventral view.
c, peripheral view.

Description. — Test typically attached, plano-convex, dorsal side flattened or slightly concave, ventral side convex, all chambers visible on the dorsal side, only those of the last-formed whorl seen on the ventral side; peripheral margin subacute, carinate except a few later chambers with rounded peripheral margin; sutures more or less depressed on the ventral side, thickened on the dorsal side; wall coarsely perforate; aperture forming an arched opening at the periphery, extending along the basal margin of the last-formed chamber.

Diameter, about 0.95 mm.

Localities. — This species was obtained at all stations, 4–33 fathoms deep, where the collections were made.

Remarks. — This species is common in Mutsu Bay as also in Oshoro Inlet, Hokkaido (1929). This species seems to be variable in shape to the adherent mode of life. CUSHMAN (1915) reported the occurrence of this species from off Japan, but he did not mention the station.

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Contribution to the Knowledge on the Soil Microflora of *Pseudosasa*-association.[1] I.

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(With 3 text-figures.)

INTRODUCTION.

In the year 1929, there was erected a botanical station on the mountain side of Hakkôda in the Prefecture of Aomori as a branch of our Institute. To describe in detail the geographical situation of the station or to make general remarks on the vegetation in the neighbourhood may here be dispensed with, because they are to be found in papers by other experts in those respective lines[2]. It is sufficient for the scope of the present paper to mention only that the said station, being situated near the northern end of Honsyû, at an elevation of some 900 meters above sea-level, is surrounded with a wide and luxuriant vegetation of *Pseudosasa kurilensis* Makino (syn. *Sasa kurilensis* Makino et Shibata).

The genus of *Pseudosasa*[3], belonging to the so-called bamboo group, is distributed quite widely throughout our country, from Kyûsyû northwards as far as the Kurile Islands and Saghalien. Although the number of species assigned to this genus up to this day is not abundant, some of them are remarkable for the wide range of their distribution, and especially so is *Pseudosasa kurilensis* Makino (Japanese name, Nemagari-dake[4]), whose association covers so wide an extent of area

[1] Contributions from the Mt. Hakkôda Botanical Laboratory, No. 6.

[2] Horikawa, Y. The Vegetation of Mt. Hakkôda. Sci. Rep., Tôhoku Imp. Univ., Ser. IV, Vol. 5, pp. 555–572. 1930.

[3] A generic name innovated by Dr. Makino: Makino, T. Journ. Jap. Bot. Vol. 2, p. 15, 1920, Vol. 5, p. 15, 1928.

[4] The plant known under this current appellation is, according to Dr. Makino's opinion, to be included in the species of *Pseudosasa kurilensis*: c. f. Makino, T. Jour. Jap. Bot., vol. 5, p. 3, 1928.

that we can find it in almost every montanic region in the northern part of Japan.[1] Naturally, its zone of distribution is not situated in the same elevation throughout the country, but is subjected to changes of level according to the latitude; we can find it in lower regions in Hokkaidô than in Honsyû, and it even occupies regions near the sea coast in Saghalien, near the border line of its distribution. In short, its extent of distribution seems to correspond roughly to those of *Fagus* and *Betula*.

So far as the whole group of bamboo are concerned, *Pseudosasa kurilensis* may not be an especially gigantic member at all among them. When well nourished, however, its culms can elongate as high as 3 meters and grow as thick as two and a half centimeters across. Moreover, it is quite hardy and resistant and often assumes a dominant position over a quite extensive area of vegetation, which displays a unique physiognomy. Indeed, it is not a rare occurrence in montanic regions that it builds up so dense a thicket that it is an exceedingly hard task for mountaineers to pass through.

Taking into account the wide extent of its distribution, combined with its luxuriant growth, it may be easily granted that *Pseudosasa*-association is an important element in the phytogeography of Japan and a very interesting object to study. The circumstance that a botanical laboratory was established in the midst of *Pseudosasa*-association induced the writer to study it and especially the microbiology in the soil of the vegetation. As is generally recognized, the multiplication of the microbes and particularly that of the bacteria is often wonderfully rapid and their generations are quite short, so that if it takes a long time from the sampling of the material to the commencement of the actual investigation, the plating in the PETRI dish, the changing conditions in the meantime will naturally influence in some way or other the microflora of the material and the result of such study may often be open to question. Of course, such is not always the case with all microbiological study and some investigations may be equally well performed with an old material as a new one, but, for some other studies, for instance, counting the number of

[1]The biology of this plant is to be found in: UCHIDA, S. Nemagari-dake no Kenkyû (Studies on Nemagari-dake), text in Japanese. The Scientific Researches, The Alumni Association of the Morioka Agr. College. Vol. 1. pp. 33 45, 1923.

microbes by the plate method, the use of fresh material is almost imperative. At any rate, it is of no little advantage to be in supply of as fresh material as possible. The data reported in the present paper are all obtained with fresh material, that is, the soils were collected in or near the compound of the station and subjected to study directly after the sampling. The study was commenced in the summer of 1929 and was repeated in the summer of 1930, which yielded some knowledge along this line of the problem. These results are, of course, still incomplete and far from satisfactory, yet some suggestions may be derived from them which may not be without use in the event of further study in the future. Hence a brief preliminary report about them here.

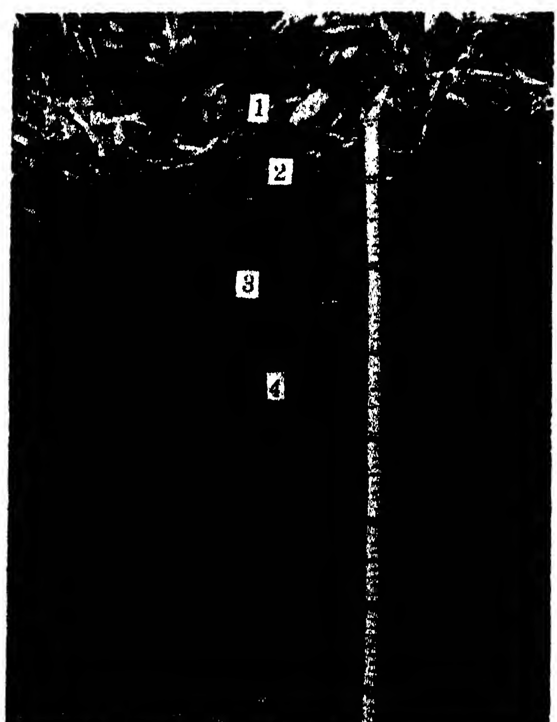
MATERIALS FOR THE STUDY.

The materials for the present study were obtained from the soil of the *Pseudosasa kurilensis*-association on Mt. Hakkôda. Two locali-

Text-fig. 1. *Pseudosasa*-association Locality No. 1. Aug., 1930. HAYASI photo.

ties were selected, one in the compound of the station and the other a little away from it. The general features concerning these two localities are briefly described in the following.

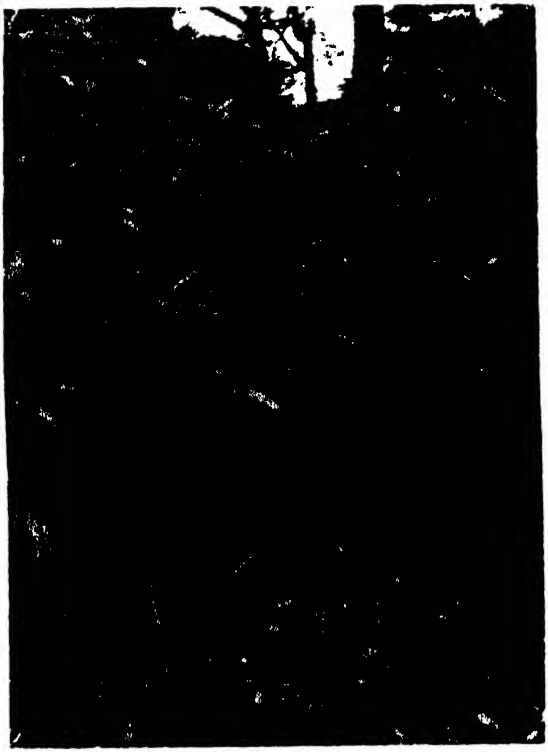
Locality No. 1. *Pseudosasa kurilensis*-association in the compound of the station. Elevation, ca. 900 m. above sea-level. No appreciable inclination. The general features of the vegetation are shown in Text-fig. 1. As is shown in this text-figure, a dominant position is maintained by *Pseudosasa kurilensis* MAKINO, and dispersed in the thicket we can find shrubby plants such as *Ilex Sugeroki* MAXIM. subsp. *brevipedunculata* MAKINO, *Acer spicatum* LAM. var. *ukurundense* MAXIM., *Acer distylum* SIEB. et ZUCC., *Sorbus Aucuparia* L., *Daphniphyllum humile* MAXIM., such climbing ones as *Rhus toxicodendron*



Text-fig. 2. Section of the ground of *Pseudosasa*-association.
1. layer of undecomposed leaves; 2. layer of *Pseudosasa* rhizomes; 3. layer still rich in organic matter; 4. clayey soil layer with poor organic matter content. Aug., 1931, HAYASI photo.

L. var. *vulgaris* PURSH. f. *radicans* ENGL. and *Crawfurdia trinervis* MAKINO, and such undergrowth as *Skimmia japonica* THUNB., *Majanthemum bifolium* DC., *Cornus canadensis* L., *Trientalis europaea* L. etc. The ground is covered with a few centimeters thick layer of dead leaves of plants, mainly of *Psudosasa kurilensis*. These leaves are only slightly decayed so that the original shapes are still to be recognized quite easily. Underneath comes another stratum whose soil is interwoven with rhizomes of *Ps. kurilensis*, which assume a dense anastomosis. The thickness of this layer measures roughly 10 to 15 centimeters. The soil is black and characterized by the high percentage of organic matter in it. From this layer downwards, the organic matter content in the soil decreases gradually until at last at the depth of a little over 30 centimeters appears a quite distinct soil layer. This latter consists of clayey soil of brown ochre-like color, easily distinguishable from the overlying one by its poor content of organic matter. Sections of the soil layers are shown in Text fig. 2. As materials for study, samples were collected at three layers of different depths, viz., A) 3–6 cm., B) ca. 30 cm., C) ca. 55 cm. (depth measured without the superposed layer of undecomposed dead leaves). Some remarks with regard to the materials are given in Table 1.

Locality No. 2. *Pseudosasa kurilensis*-association, some 2.5 km. away from the laboratory. About 1000 m. high above sea-level. Inclination, 20°–30° facing southward. The general features are shown in Text-fig. 3. *Fagus Sieboldi* and *Ps. kurilensis* assume dominant positions in this locality, the former in the upper storey and the latter in the lower. *Oxalis acetocella* L. var. *japonica* MAKINO, *Plagiogyria Matsumuraeana* MAKINO, *Clitonia udensis* TRAUTV. et MEY., *Dryopteris spinulosa* KUNTZE var. *dilatata* UNDERW. etc. are found interspersed between. The appearance of the surface of the soil is not materially different from that of locality No. 1, that is, the uppermost few centimeters are composed of dead but almost undecomposed leaves of *Ps. kurilensis*. When stripped of this surface layer, we can find the underlying black soil, rich in organic matter and with strong acidic reaction. Sampling was made at a depth of 3 to 6 cm. exclusive of the surface layer of undecomposed leaves. The general properties are shown in Table 1 (D and D′), with some other remarks. As for



Text-fig. 3. *Pseudosasa*-association Locality No. 2.
Aug., 1931, OKADA photo.

the deep soil of this locality, no study has been undertaken up to this day and we can not tell how thick the humus layer here measures.

NUMBER OF BACTERIA AND MOULDS ESTIMATED BY THE PLATE METHOD.

Ordinary peptone-decomposing bacteria of aerobic life, the same growing under anaerobic conditions, moulds and urea-decomposing bacteria in the soil were each enumerated by the plate method. The culture media applied in these studies are briefly described in the following lines.

a) For ordinary peptone-decomposing aerobic bacteria:— Soil extract agar of pH 7.0 was employed in the study, and garden soil from our Institute in Sendai was applied in preparing the extract.

TABLE 1. Materials of the Study.

	Locality	Depth, cm.	Date & Hour of Sampling	Temperature		Water Content on the Basis of:—		Loss on Ignition %	pH
				Air	Soil	fresh weight %	air dried weight %		
A	In the compound of the station	3-6	27/VII, 1930 11 h.	28°	18°	77.6	9.5	60.9	4.6
A′	"	"	23/VII, 1929 15 h.	25°	17°	76.4	/	59.3	4.4
B	"	ca. 30	28/VII, 1930 11 h.	26°	16°	47.8	6.4	23.0	5.0
C	"	ca. 55	"	26°	13.5°	48.9	13.1	9.0	4.8
D	At the foot of Mt. *Isikura*	3-6	23/VII, 1930 12 h.	22°	15°	71.8	/	41.7	4.7
D′	"	"	22/VII, 1929 11 h.	24°	17°	65.4	/	45.3	4.4

Sample A represents a mixture of 15 collections, A′, D and D′ mixtures of 10 collections, B and C each single collection. pH was determined by GILLESPIE's[1] colorimetric method with the water extract prepared after the method of ARRHENIUS[2]. In 1929, air dried samples were employed to make the extract, while, in 1930, fresh soils were applied as soon as they were collected. It was with the counterpart of the samples in this table that the bacteriological studies described below were accomplished.

The preparation was executed after the receipt of LOEHNIS[3] and talcum powder was employed to facilitate the filtration. 15 g. of Agar was added to 1000 cc. of soil extract.

b) For anaerobic peptone-decomposing bacteria:—The same culture medium as in a) was applied in this case. The plates were kept in glass jars in which the anaerobic condition was produced by mixing 6 parts of 60% aqueous solution of caustic soda with 1 part of 25% aqueous solution of pyrogallic acid.[4]

1) CLARK, W. M. The determination of Hydrogen Ions. 2 ed. pp. 128-131, 1923.
2) ARRHENIUS, O. Kalkfrage, Bodenreaktion und Pflanzenwachstum. pp. 92-93, 1926.
3) LOEHNIS, F. Handbuch der landwirt. Bakteriologie. p. 521, 1910.
4) MEYER, A. Praktikum der botanischen Bakterienkunde. p. 148, 1903.

c) For moulds:—The medium recommended by WAKSMAN[1] to study the number of soil fungi was adopted. The composition is; water 1000 cc., glucose 10 g., peptone 5 g., KH_2PO_4 1 g. $MgSO_4 7.Aq.$ 0.5 g., agar 30 g. The reaction was adjusted to pH 4.0.

d) For urea-decomposing bacteria:—The medium described by KLEIN and STEINER[2] (p. 305) to count the number of the urea-decomposing bacteria was applied. This is of the following composition; water 1000 cc., urea 50 g., Na-acetate 10 g., KH_2PO_4 0.25 g., gelatin 120 g., and some CaCl.

PETRI dishes of 9 cm. width were used and into each dish was poured 10 cc. of the culture media. Other conditions of incubation and the results of counting are tabulated in Table 2.

TABLE 2. Numbers of Various Groups of Microbes.

Group	Material	Dilution	Number of Plates	Incubation		Number of Colonies per Plate (average)	Approximate Germ Number per 1 g. of Fresh Soil
				Temp.	Period in Days		
Peptone-bacteria, aerobic*	A	1/100000	10	28°	12	13.5	1400000
,,	A′	1/10000	5	25°	10	77.8	780000
,,	D′	1/10000	5	25°	10	145.8	1460000
Peptone-bacteria, anaerob.**	A	1/1000	5	room temp.	12	239.5	240000
Mould	A	1/1000	5	28°	5	16.2	16000
Urea-bacteria	A	1/100	5	28°	12	2.8	280

*Some actinomycetes are included. **The differentiation of obligate anaerobic species from facultative ones was not undertaken.

As has already been mentioned above (see Table 1.), the reaction of the soil in our study is decidedly acidic, which naturally allows the presumption that the bacterial number in such a soil cannot be very remarkable. The result of actual experimentation proved, as is

[1] WAKSMAN, S. A. A method for counting the number of fungi in the soil. Journ. Bact., Vol. 7, pp. 339–341, 1922.

[2] KLEIN, G. und STEINER, M. Bakteriologisch-chemische Untersuchungen am Lunzer Untersee. Oester. Bot. Zeitschr. Vol. 78, p. 305, 1929.

shown in Table 2, that the above view holds good in the present case. Indeed, the number of peptone-decomposing bacteria in the Pseudosasetum soil is far below that of ordinary loamy soil. Anyhow, it is materially proved that there exists in this soil a not negligible number of bacteria both aerobiont and anaerobiont, and that they are sure to play some rôle in the decomposition of the organic matter in the soil. The number of urea-decomposing bacteria in this soil is extremely poor, so that the activity of this kind of bacteria is not to be highly appreciated. As for the question of the fungal flora, it seems that the temperature applied in the study was somewhat too high for them. Some of the fungi in the Pseudosasetum soil seem to be rather quick growers at this temperature and we could not continue the counting beyond the fourth or fifth day of incubation, so that such individuals as are slow to establish colonies were naturally left out of the count. Therefore the results in the above table with respect to the fungi must be too low, and it is eagerly desired to repeat studies about the matter in order to approximate the actual number. The ratio of moulds to the aerobic peptone bacteria is reckoned to be about 1.2% so far as the data in the above table are respected, but this value may also be open to some correction.

CELLULOSE DECOMPOSING BACTERIA.

Bacterial decomposition of cellulose in the soil is known to be performed both with and without air supply, and for the purpose of the isolation of these organisms various culture media have been introduced up to this day. To get some knowledge about the matter in the Pseudosasetum soil, some experiments were performed with the two culture media below, one for the aerobic and the other for the anaerobic organisms, the former being adopted from DUBOS[1] and the latter from OMELIANSKY[2].

a) For aerobic organisms:—$NaNO_3$ 0.5 g., K_2HPO_4 1.0 g., $MgSO_4$ 7 Aq. 0.5 g., KCl 0.5 g., $FeSO_4$7 Aq. 0.01 g., water 1000 cc. pH 7.5. Test tubes containing 10 cc. of the medium each with a strip of filter

[1] DUBOS, R. J. The decomposition of cellulose by aerobic bacteria. Journ. Bact. Vol. 15, pp. 223–234, 1928.

[2] OMELIANSKY, W. Ueber die Gaerung der Cellulose. Centrbl. Bakt. II. Vol. 8, p. 226, 1902.

paper dipped in were applied for the culture. The upper fourth or fifth of the paper was kept above the niveau of the medium.

b) For anaerobic organisms :—$CaCO_3$ 20 g., K_2HPO_4 1.0 g., $MgSO_4$ 7 Aq. 0.5 g., $(NH_4)_2SO_4$ 1.0 g., NaCl trace, water 1000 cc. pH 7.3. In this case, too, test tubes were applied as cultute vessels. The medium filled in these tubes was covered with a layer of liquid paraffin about 1 cm. thick.

Inoculation was made from samples A, B, and C of Table 1, that is, the soil of *Pseudosasa*-association in the compound of the station and at the depth of 3–6, ca. 30, and ca. 55 cm. The amounts of soil added to the culture tubes were, 1, 1/10, 1/100, 1/1000 and 1/10000 g., and duplicate or quadruplicate cultures were prepared. In the case of the application of 1 g., the soil as such was put directly into the culture tube. In the case of 1/10, 1/100 g. and so on, the original soil was first diluted with a proper quantity of sterile water, and a certain volume, usually 1 cc., of the diluted sample, calculated to correspond to so much of the weight of the soil as the case demands, was added to the culture tube. The same procedure was practiced in the study of denitrification bacteria described below. The results obtained after 76 days incubation at room temperature are arranged in Table 3.

As is shown in this table, few cases of positive results were

TABLE 3. Cellulose Decomposition.

Material	Oxygen Relation	Amount of Inoculated Soil in g.																	
		1		1/10				1/100				1/1000				1/10000			
A 3–6 cm. deep	aerobic	+, f	+, f	±, f	−, f	−, f	−	±, f	−	−	−	−	−	−	−	−	−	−	−
	anaerobic	+	+	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−
B ca. 30 cm. deep	aerobic	−, f	−	−, f	−			−	−			−	−			−	−		
	anaerobic	+	−	+	−			−	−			−	−			−	−		
C ca. 55 cm. deep	aerobic	−, f	−	−, f	−			−	−			−	−			−	−		
	anaerobic	−	−	−	−			−	−			−	−			−	−		

+, positive result; −, negative result; ±, decomposition but very poor; f, fungal growth.

obtained with DUBOS' medium inoculated with soils of 3–6 cm. depth. These positive examples were, however, all contaminated with soil fungi, and moreover, the decomposition of cellulose was observed exclusively at the area of fungal hyphae. Hence the natural conclusion is that the decomposition here is entirely due to fungal agency and that such cellulose-decomposing bacteria as are capable of growth in DUDOS' medium are not to be found in the present material. Nor is the presumption improbable that the cellulose decomposition in this type of soil is, so far as the liberal supply of oxygen is allowed, not so much due to the activity of bacteria as it is to that of moulds, and if a culture medium were applied more acidic than that in our experiment, we might have obtained far more vigorous decomposition thanks to the probable luxuriant growth of moulds. As for the soils collected from deeper layers, we could not attain to any decomposition of cellulose in the aerobic condition.

On the other hand, the cellulose decomposition under anaerobic conditions seems to be effected by bacterial agency. Inoculation of soil from both 3–6 cm., and ca. 30 cm. deep yielded some cases of positive result. Moreover, it was noticed that the decomposition in these cases was far more vigorous when compared with that by fungal activity mentioned just above. From these observations we can conclude that the decomposition of cellulose in the Pseudosasetum soil seems to be effected for the most part by some anaerobic species of bacteria. As for the number of such kind of bacteria in the soil, we could not obtain any exact notion. It may be stated only that they cannot be very numerous. Soils in deeper layers, say 55 cm., entirely lack such organisms.

The reaction of both the media employed in this study lies, as is above described, somewhat on the alkaline side of neutrality, differing not a little from the state of the matter in the actual soil of the study, which is decidedly acidic. So that, in order to know about the real mode of cellulose decomposition in the soil, it may be quite helpful to test it with other media having a reaction similar to that in the soil, or to experiment in regard to the actual decomposition of cellulose in the natural state of the soil. A few such studies are now under investigation and I hope to report further on this problem in the future.

DENITRIFICATION.

In order to obtain further some knowledge about the denitrification process in the Pseudosasetum soil a series of cultures was kept under the conditions described below.

Culture medium :—One of BEIJERINCK's[1] receipts was adopted, viz., mannit 20 g., KNO_3 10 g., K_2HPO_4 0.5 g., water 1000 cc. pH value ca. 7.7.

Inoculation :—10 cc. of the medium in each test tube was inoculated with 1, 1/10, 1/100, 1/1000, and 1/10000 g. of soil in a way similar to that in the preceding case. Cultures were made in quadruplicate. Only the upper layer (3–6 cm. deep) of the soil was subjected to the study.

Incubation :—75 days, at a room temperature of not lower than 20° at least.

Test of the result :—N_2O_3 and NH_3 were determined quantitatively by a DUBOSQUE colorimeter with ILOSVAY's and NESSLER's reagents respectively. As the sterilized culture medium contained trace of NH_3 from the outset, the value of NH_3 obtained after the incubation period was corrected with the value of the blind test. As for N_2O_3, the control tube was entirely free from it. N_2O_5 was proved qualitatively by the diphenylamin test after the N_2O_3, if any, was destroyed with urea and acetic acid. The result is shown in Table 4.

TABLE 4. Denitrification.

Amount of Inoculated Soil in g.	1				1/10				1/100				1/1000				1/10000			
Gas Evolution	+	+	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−
N_2O_5 Test	−	−	−	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Production of N_2O_3, mg. per Tube	0	0	0	0	0.056	0.018	0.018	0.053	0.15	0	0.12	0	0	0	0.11	0	0	0	0	0
Increment of NH_3, mg. per Tube	—	—	—	—	−0.019	−0.021	−0.007	−0.009	−0.011	−0.014	−0.020	−0.007	−0.014	−0.022	−0.014	−0.023	−0.017	−0.023	−0.021	—

[1] BEIJERINCK, M. W. und MINKMAN, D. C. J. Bildung u. Verbrauch v. Stickoxydul durch Bakterien. Centrbl. Bakt. II. Vol. 25, p. 35, 1910.

It is shown that, so far as the denitrifying bacteria in our culture are concerned, their activity seems not to be very vigorous except when the soil sample was added in a large quantity. The complete destruction of N_2O_5 took place only in the tubes inoculated with 1 g. of soil. On the contrary, the presence of N_2O_5 was decidedly established in all the other tubes. Production of N_2O_3 on the other hand, was proved positively with some tubes inoculated with 1/10, 1/100, or 1/1000 g. of soil, but the amount of this substance elaborated was rather scanty. The test for this in tubes of 1 g. or 1/10000 g. of soil was always negative. Further, we could not establish a single case of increment of NH_3 with all the culture tubes. On the contrary, some decrement, although not very considerable, was noticed. In tubes inoculated with 1 g. of soil, the medium was stained deep with the color due to humic matter which made the accurate determination of NH_3 impossible, but it seems certain at least that in these tubes, too, the NH_3 production could not be very considerable. Evolution of gas, (perhaps nitrogen) was noticed in all of the tubes with 1 g. of the soil and also one tube with 1/10 g. of soil. All other cultures were negative in this respect.

From the data thus far described, we may conclude that the vigorous reduction of N_2O_5 to N_2O_3 seems not to be expected in the present soil. Still more improbable seems the production of NH_3. As for the complete reduction of N_2O_5 to nitrogen gas, the microbes engaging in this process are sure to be found in the present soil, whose activity is quite appreciable although the actual number in the soil seems not to be very high. (Another assumption is not impossible, namely, that the organisms in question existed also in the tubes inoculated with less than 1 g. of soil, but that the culture medium, when only 1/10 g. or less of soil was added, was short of the proper organic matter to activate the bacteria. This matter will be treated in a future study.)

In connection with the reduction of nitrate, other processes of the nitrogen cycle, for instance, the oxidation of ammonia to nitrite and further to nitrate, were also investigated with the same sample. This study is, however, not yet complete and the report is laid over until further additional data are obtained. Only it may be mentioned here that the preliminary test hitherto accomplished suggests that such

transformation seems not to be very active in this soil.

In conclusion, the writer makes sincere acknowledgement to Prof. Dr. YOSHII, Director of the Laboratory, for his kindness in facilitating the present study.

Über die Entwicklung des nackten Embryos von *Crinum latifolium* L.

Von

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(Mit 5 Textfiguren.)

(Eingegangen am 28. Dezember 1930.)

Crinum latifolium L., eine Spezies der Amaryllidaceen, ursprünglich aus Ostindien, wird in Japan manchmal im Garten als Zierpflanze gezüchtet. 1928 berichtete NAKAJIMA eine interessante Tatsache über diese Pflanze. Er schreibt: „Die kleinen, dem nackten Embryo ähnlichen Körperchen, welche sich meistens in den durch Selbstbefruchtung erzeugten Früchten neben den echten Samen in grosser Zahl befinden, sind keineswegs Reste ungereifter Samen. Sie besitzen beinahe die gleiche Eigenschaft wie der echte Embryo und zeigen, mit Zucker ernährt, ein sehr ähnliches Wachstum wie der vollständige Embryo, welcher aus dem Samen entnommen und ebenfalls mit Zucker kultiviert wurde. Wenn man in einen Samen ein kleines Loch bohrt und dieses Körperchen hineinsteckt, so kann es sich langsam auf Kosten der Nährstoffe im Endosperm des Samens weiter entwickeln. Dieser Versuch macht es wahrscheinlich, dass dies Körperchen dem endospermfreien nackten Embryo entspricht."

Um diese Erscheinung zytologisch noch genauer zu untersuchen, habe ich dieses Jahr einige Blütenknospen dieser Pflanze fixiert. Mein Material stammte von einigen Exemplaren, die NAKAJIMA vor einigen Jahren von Tokyo mitgebracht und in den hiesigen botanischen Garten umgepflanzt hatte. Als Fixierungsflüssigkeit verwandte ich durchweg die BOUINsche Lösung. Die Mikrotomschnitte waren 20 bis 25 μ dick. Zur Färbung wurde HEIDENHAINS Eisenalaun-Hämatoxylin oder Gentianaviolett nach NEWTON benutzt. Um möglichst viele der oben genannten Embryonalkörperchen zu gewinnen, wurde hauptsächlich Selbstbestäubung vorgenommen. Nach Bestäubung wurden die Blumen mit einer Paraffinpapiertüte bedeckt, die dann nach einigen Tagen wieder entfernt

wurde, um jedwede schlechte Einflüsse auf die Samenentwicklung auszuschliessen.

Obwohl die Embryosackentwicklung dieser Pflanze schon von STENAR (1926) untersucht wurde, ist doch die Embryoentwicklung bis jetzt von niemand verfolgt worden. Wie wohl bekannt, zeigt der Fruchtknoten dieser Pflanze im Querschnitt sechs anatrope Samenanlagen, je zwei in jedem Fach (Fig. 1) und jede Samenanlage hat kein Integument (GÖBEL, 1889) (Fig. 2). Die erste Kernteilung in der Embryo-

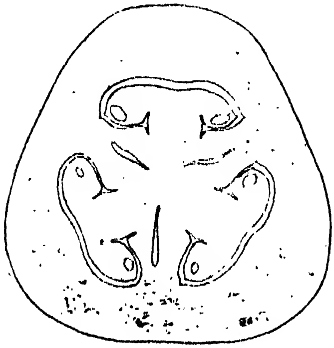

Fig. 1. Querschnitt durch einen Fruchtknoten. Vergr. 17:1.

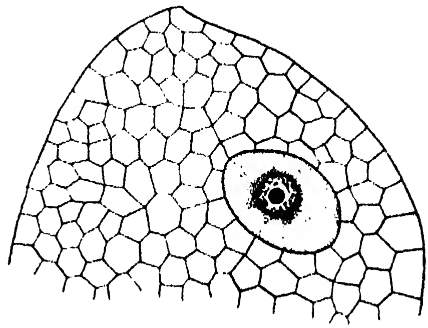

Fig. 2. Jüngere Samenanlage mit einer Embryosackmutterzelle. Vergr. 164:1.

sackmutterzelle ist heterotypisch. Dabei wurden 12 Doppelchromosomen gezählt (Fig. 3, b). Dies ist die haploide Chromosomenzahl dieser Pflanze, da in der Wurzelspitzenzelle 24 Chromosomen gefunden werden (Fig. 3, a). Nach SCHLIMBACH (1924) entsteht der Embryosack einer *Crinum*-Art nach dem Liliumtyp. Aber bei meiner Art erfolgt die Embryosackbildung, wie schon STENAR (1926) gezeigt hat, wahrscheinlich nach dem Scillatyp (Fig. 3, c, d, e); die durch homöotypische Teilung entstandenen zwei Kerne weichen auseinander, ohne dabei eine Zellhaut zwischen sich zu bilden (3, d) und teilen sich ein jeder an den Polen des Embryosacks erst in zwei (3, e) und danach in vier. In dieser Weise entsteht ein Embryosack des gewöhnlichen Typs. Der untere Teil des Embryosacks ist meistens grösser als der obere. Die Eizelle enthält in ihrem basalen Teile eine Vakuole (Fig. 3, h). Sie ist aber in den Synergiden nie vorhanden. Die beiden Polkerne wandern gegeneinander in der Nähe der Antipodenzellen (Fig. 3, f, g) und vereinigen sich zum sekundären Embryosackkern (Fig. 3, h). Die

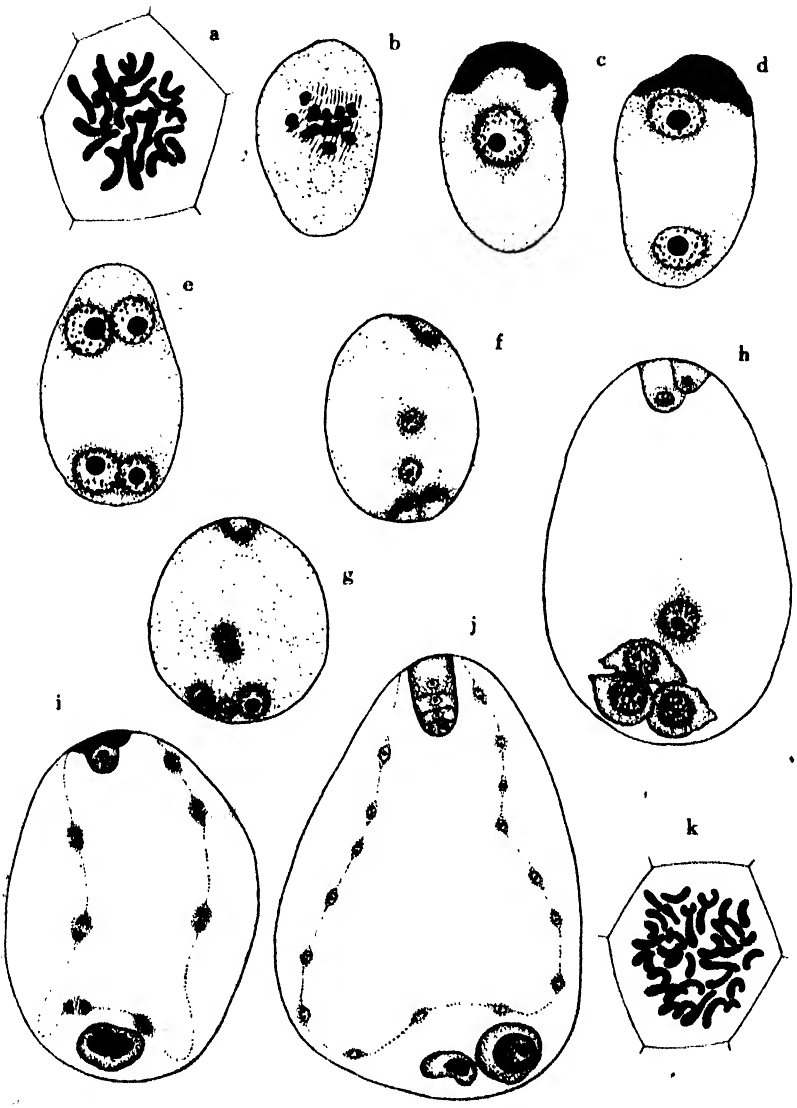

Fig. 3. a, Polansicht der Kernteilung in der Wurzelspitzenzelle. Vergr. 518:1. b, die erste Kernteilung in der Embryosackmutterzelle. c–h, Embryosackentwicklung. c, einkerniges Stadium. d, zweikerniges Stadium. e, vierkerniges Stadium. f–h, fertiger Embryosack. Vergr. b–h, 204:1. i–j, nukleäre Endospermbildung. Vergr. 81:1. k, Polansicht der Kernteilung in einer Endospermzelle. Vergr. 812:1.

Antipodenzellen, gewöhnlich drei, selten vier, sind sehr gross, und jede von ihnen enthält einen grossen chromatinreichen Kern. Obwohl ich die Erscheinung der Befruchtung bedauerlicherweise nicht beobachten konnte, so steht doch fest, dass der sekundäre Embryosackkern zugleich mit der Teilung der befruchteten Eizelle sich zu teilen beginnt. Beim früheren Stadium der Endospermentwicklung erfolgt keine Zellhautbildung, also die nukleäre Endospermentwicklung wie bei *Crinum asiaticum* (SCHLIMBACH 1924) (Fig. 3, i, j). Bei der Kernteilung in einer Endospermzelle wurden 36 Chromosomen gezählt (Fig. 3, k). Nach GÖBEL (1889) kommt der Embryo von *Crinum asiaticum* durch das peripherische Wachstum des Endosperms annähernd in die Mitte des Endosperms zu liegen, sich von seiner Haftstelle losreissend. Dieselbe Erscheinung zeigt sich auch bei meiner Art (Fig. 4, b). Mit dem Fortschreiten der Endospermentwicklung wird das Nuzellusgewebe allmählich durch das Endosperm zerstört (Fig. 4, a) und in den reifen Samen vollständig absorbiert. Also ist der Samen dieser Pflanze tenuinuzellat, wie schon GÖBEL (1889) bei *Crinum asiaticum* und STENAR (1926) bei dieser Pflanze behauptet hat. Später entsteht eine

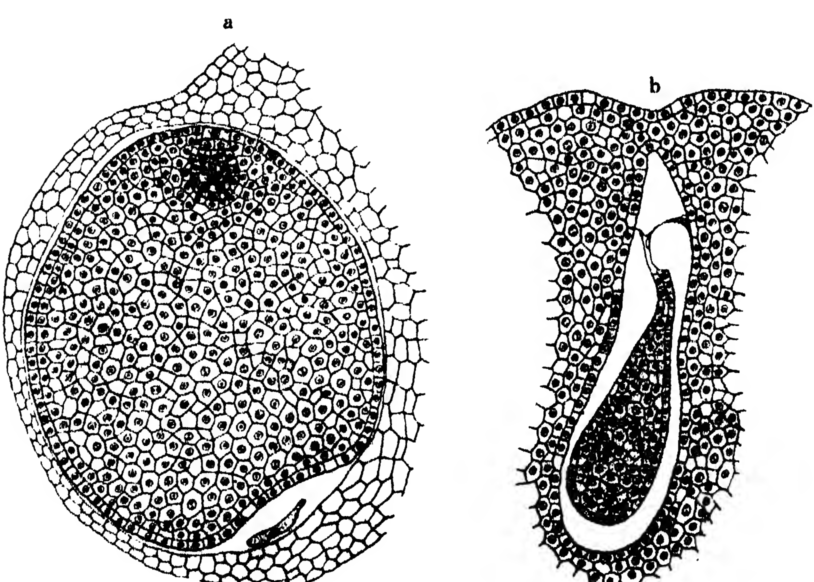

Fig. 4. a, fortgeschrittenes Stadium der Endospermbildung. Vergr. 48:1. b, von der Haftstelle losgerissener Embryo. Vergr. 75:1.

Korkschicht in der Peripherie des nackten Endosperms. Dies ist auch der Fall bei *Crinum asiaticum* (GÖBEL 1889).

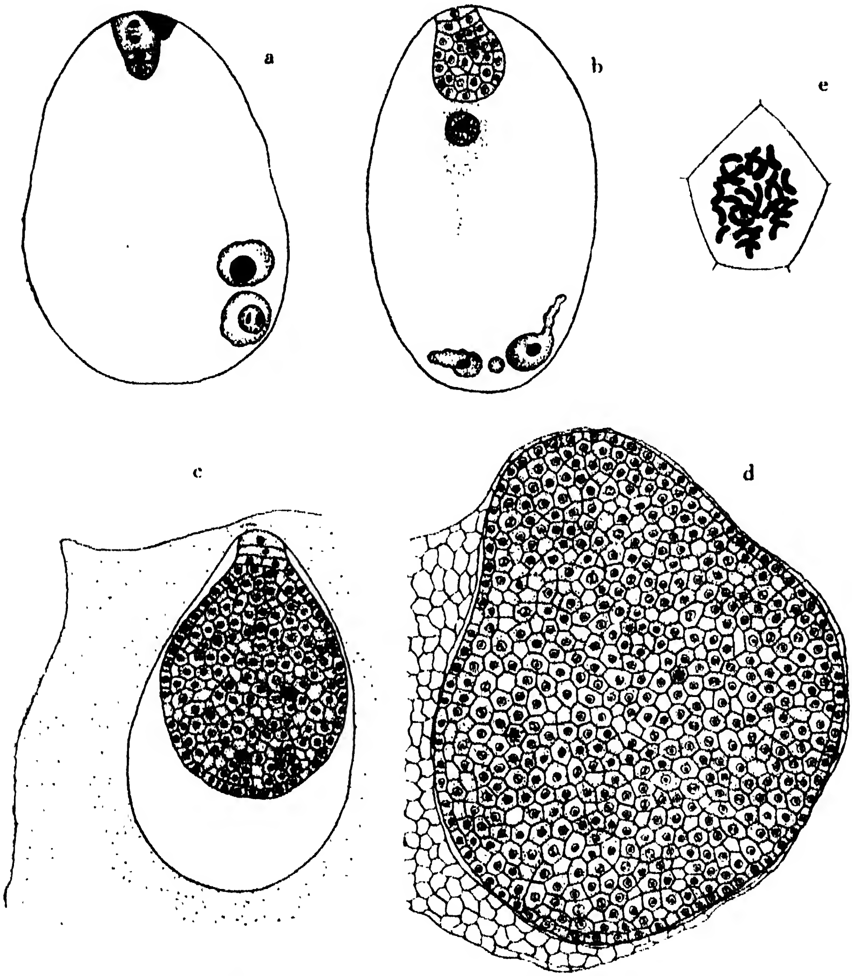

Fig. 5, a–d, Entwicklung des nackten Embryos. Vergr. 73:1. e, Polansicht der Kernteilung in einer Zelle des Embryos. Vergr. 463:1.

So weit über die normale Samenentwicklung dieser Pflanze. Nun werde ich auf die Beschreibung der Entstehung des nackten Embryonalkörperchen eingehen. Zuerst habe ich gefunden, dass die Embryoentwicklung manchmal nicht mit der Teilung des sekundären Embryosackkerns begleitet wird. Einen solchen Fall zeigen Fig. 5, a und b.

Dort kann man sehen, dass ungeachtet des normalen Fortschreitens der Embryobildung der sekundäre Embryosackkern noch ungeteilt geblieben ist. Fig. 5, c zeigt ein noch späteres Stadium eines ähnlichen Embryosacks. Obwohl das Nuzellusgewebe in diesem Stadium noch vorhanden ist, wird es doch allmählich durch den Embryo zerstört (Fig. 5, d). Der in dieser Weise entstehende Embryo zeigt am Ende eine normale Differenzierung des Körpers in Kotyledonen, Plumula und Radicula. Es scheint mir sehr wahrscheinlich, dass die von NAKAJIMA untersuchten „ dem nackten Embryo ähnlichen Körperchen " in dieser Weise entstehen und in Wirklichkeit nichts anders als echte Embryonen sein dürften.

Es würde interessant sein, zu bestimmen, ob im Anfang der Entwicklung des in solcher Weise entstehenden nackten Embryos die Doppelbefruchtung normal vor sich geht oder nicht. Da die Chromosomenzahl des nackten Embryos auch diploid ist (Fig. 5, e), liegt die Vermutung ziemlich nahe, dass nur der eine der zwei Spermakerne sich mit der Eizelle und der andere sich nicht mit dem sekundären Embryosackkern vereinigt. GUIGNARD (1922) hat einen solchen Fall in Wirklichkeit bei *Vincetoxicum nigrum* gefunden. Nach ihm verlässt bei dieser Pflanze nur ein Spermakern den Pollenschlauch und vereinigt sich mit der Eizelle, aber der andere ist im Pollenschlauch zu sehen, während der Embryo aus der Eizelle entsteht.

NAKAJIMAS Kastrationsversuch zeigt auch, dass nach solcher Behandlung bei unserer Pflanze nie nackte Embryonen entstehen. Also die Möglichkeit, dass die nackten Embryonen parthenogenetisch entstehen, kann mit voller Sicherheit als ausgeschlossen betrachtet werden.

ZUSAMMENFASSUNG.

1. *Normale Samenentwicklung.*
   (a) Im Anfang der Embryoentwicklung erfolgt eine Reduktionsteilung. Die haploide Chromosomenzahl beträgt 12.
   (b) Die fertige Struktur des Embryosacks ist ganz normal. Entwicklungstyp des Endosperms nukleär. Triploide Chromosomen sind bei der Kernteilung der Endospermzelle zu sehen.
   (c) Die Samenanlage hat von Anfang an kein Integument. Der Nuzellus wird von dem Endosperm allmählich absorbiert.

Samen dieser Pflanze haben also keine Hülle ausserhalb des Endosperms.

2. *Entwicklung des nackten Embryos.*
   (a) Der nackte Embryo entsteht aus einer befruchteten Eizelle, ohne Endospermentwicklung.
   (b) Der Nuzellus wird auch vom wachsenden Embryo allmählich absorbiert. Am Ende der Embryoentwicklung besteht also ausserhalb des Embryos nichts.

Herrn Dr. Prof. M. TAHARA, unter dessen Leitung vorliegende Arbeit ausgeführt wurde, möchte ich auch hier meinen herzlichen Dank aussprechen. Ebenso bin ich auch Herrn NAKAJIMA für seine nützlichen Ratschläge zu grossem Dank verpflichtet.

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Report of the Biological Survey of Mutsu Bay.
20. Echiuroidea.[1]

By

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(With 4 text-figures.)

(Received March 2, 1931.)

The Echiuroidea collected by the Biological Survey of Mutsu Bay is represented by only two species belonging to different genera. They are *Urechis unicinctus* (VON DRASCHE) (Text-figs. 1–3) and *Ikeda taenioides* (IKEDA) (Text-fig. 4).

Of these two species the former is rather common, being found at several localities in Mutsu Bay, while the latter is imperfectly known, only the proboscis of the animal being obtained.

I wish to express my sincere thanks to Professor S. HÔZAWA for his kind advices given during the course of the present investigation.

DESCRIPTION OF THE SPECIES.

Genus URECHIS SEITZ.

Prae-oral proboscis short, scoop-shaped. Two genital hooks exist close to and behind the mouth, and a circle of anal hooks surrounds the anus. Two or three pairs of segmental organs, each provided with two long spiral extentions of the lips of the coelomic aperture. Alimentary canal long, convoluted. A spacious rectum which serves as a respiratory organ, is led to a muscular cloaca. Two anal vesicles are attached to the cloaca at its ventro-lateral surface. No definite blood-system is present.

1. Urechis unicinctus (VON DRASCHE).

(Text-fig. 1–3)

Ein Echiuroid, WILLEMOES-SUHM, 1876, p. 102.

Echiurus unicinctus, VON DRASCHE, 1881, pp. 3–5, Pl. XX, Fig. 1; E. SELENKA,

[1] Contributions from the Marine Biological Station, Asamushi, Aomori-Ken. No. 63.

1885, pp. 6-7, Pls. I, III; W. FISCHER, 1895, p. 21; A. SHIPLEY, 1899 (2), p. 344; A. L. EMBLETON, 1900, pp. 77-97, Pls. VII-X, Text-fig. 1; I. IKEDA, 1904, pp. 59-60; 1924, p. 38; A. OSTROUMOV, 1909, p. 319; J. W. SPENGEL, 1921 (1), p. 356.

Urechis unicinctus, PH. SEITZ, 1907, p. 30; J. W. SPENGEL, 1912 (2), pp. 173-212; W. FISCHER, 1914 (2), pp. 1-28; 1921, p. 423.

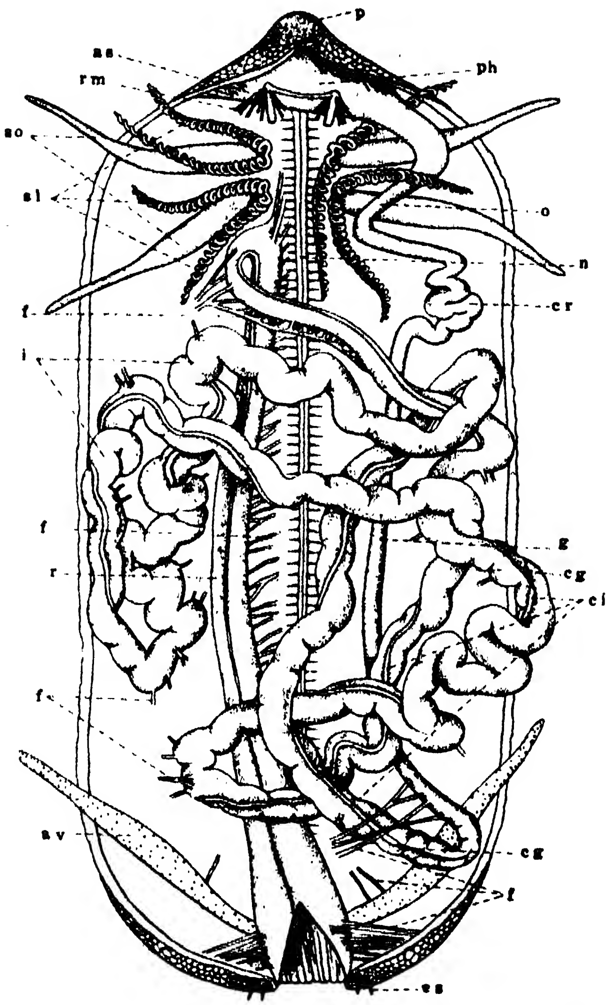
Spiroctetor unicinctus, A. S. SKORIKOV, 1909, pp. 77-102.

This species is very common and is obtainable abundantly everywhere along the coast of Japan. The fishermen use this animal as bait. In Mutsu Bay it is found in great abundance, too. This animal was reported for the first time by WILLEMOES-SUHM (1876, p. 102), who says, "Ein Echiurid der den Fischern als Köder dient und wohl in Schlamm dicht am Ufer vorkommt. Der 3-4 Zoll lange Wurm stimmt ganz mit den Merkmalen der Gattung *Echiurus* überein, hat aber hinter nicht zwei Hakenkränze, sondern nur einen." But it was not named specifically at that time. In 1881, RICHARD VON DRASCHE described this animal as a new species under the name of *Echiurus unicinctus*, using the specimens collected by A. VON RORETZ from South Japan.

Text-fig. 1. *Urechis unicinctus* (VON DRASCHE). Natural size.

I have collected a great number of specimens of this species at Moura, Nonai, and Asamushi near the Marine Biological Station.

The animal (Text-fig. 1) lives in a U-shaped tube made in the muddy sand of the sea-bottom. The inner surface of the tube is smooth being plastered with the mud mixed with mucous secretion of the worm. The tube has two apertures, one



Text-fig. 2. *Urechis unicinctus* (VON DRASCHE). Specimen dissected. as, muscle sheath of anterior ventral setae; av, anal vesicle; cg, ciliated groove; ci, collateral intestine; cr, crop; cs, caudal seta; f, fixing-muscles; g, gizzard; i, intestine; n, ventral nerve-cord; o, oesophagus; p, proboscis; ph, pharynx; r, rectum; rm, radiating-muscles; sl, spiral lips; so, segmental organs. (Natural size).

at each end. Both ends of the tube are slightly elevated above the level of the sand in the manner of short chimneys.

The said specimens measure 13-250 mm. in length and 9-30 mm.

in thickness. The smaller specimens are covered by very thin, colourless and somewhat translucent skin, while the larger ones are covered by thick, light reddish and entirely opaque skin.

The proboscis (Text-fig. 2, p) is represented merely by a bluntly-pointed prae-oral lobe of conical shape, about 5 mm. long, not showing any constriction which distinguishes the proboscis from the body proper as in the cases of *Echiurus pallasii* and of all the members of the genus *Thalassema*. In these forms, the proboscis is easily cut off at the point of the constriction, but in *Urechis unicinctus* it is not the case for the reason above mentioned. Of the present species, VON DRASCHE denied the existence of the proboscis saying, "Beide Exemplaren fehlte der Kopflappen (Rüssel)." This misunderstanding is also said to be caused from the same reason.

At the base of the proboscis-lobe exists the mouth, facing ventrally.

The whole outer surface of the body is densely covered with a large number of papillae which do not show any definite arrangement, save that they are apt to be arranged in transverse rows surrounding the body. The papillae are extremely variable both in form and size: they are sometimes roundish and sometimes elliptical in surface view, and measure 0.1–0.6 mm. in diameter at the base. In the middle region of the body proper, the papillae are comparatively small and flat; while in the regions near both extremities, they are larger measuring 0.5–1.0 mm. both in height and in diameter at the base. The papillae found on the proboscis are exceedingly small and flat. In the region of the segmental organs there exists a broad band which is beset with a number of large papillae arranged in rows.

On both sides of the ventral median line and slightly behind the mouth, there projects a pair of hooks (or setae) with their free extremities markedly recurved. They are called genital hooks (or setae) or anterior ventral hooks (or setae). Of each of the hooks two parts may be distinguished: the straight basal portion and the curved apical portion. The basal portion of the hook lies always in the body cavity enclosed in a muscular sheath supported by numerous strong radiating-muscles. (Text-fig. 2, rm). The apical portion of the hook which occupies about one-fourth of the whole length of the hook is laterally compressed and is sometimes exposed outside of the body surface but also is able to be withdrawn into the body-wall by means of the

radiating-muscles above alluded to.

At the posterior end of the body, surrounding the anus, there is a single circlet of hooks (or setae) called caudal hooks (or setae) or peri-anal hooks (or setae) (Text-fig. 2, cs). The circlet consists of 10–13 setae which are smaller and thinner than the anterior ventral setae, measuring 4–8 mm. in length. Each of the setae is nearly straight and is sharply pointed at its free extremity, while the basal three-fourths of its length are enclosed in a muscular sheath and protrude into the body-cavity. Two of these hooks placed on each side of the mid-ventral line are rather widely separated from each other; while the others are arranged almost at equidistance.

Just behind the genital hooks, on the ventral side, two pairs of minute pores are found; these are the external apertures of the segmental organs (or nephridia) (Text-fig. 2, so).

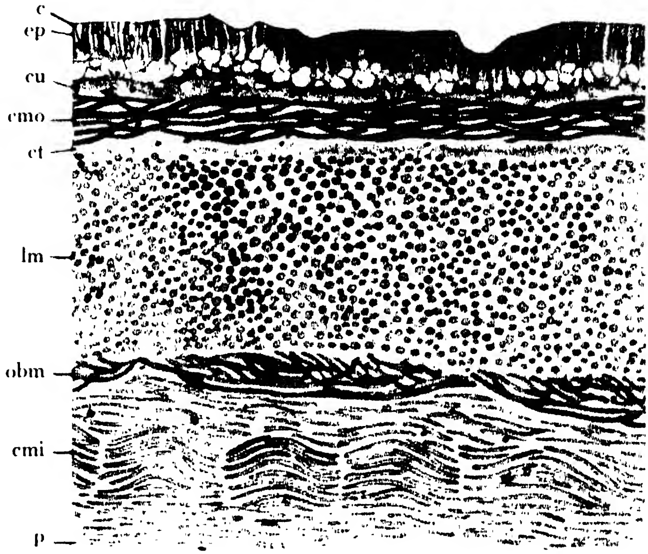
The body-wall (Text-fig. 3) is covered externally by a thin cuticle (Text-fig. 3, c). Beneath this comes the epidermal layer (Text-fig. 3, ep) which is comparatively thick and appears to be composed of cells of glandular nature. Beneath the epidermal layer there occurs the cutis (Text-fig. 3, cu), namely, a connective tissue layer. The muscle layers come next: the outermost, first layer is made up of circularly arranged fibres (Text-fig. 3, cmo); the second is of longitudinal fibres (Text-fig. 3, lm). There exists a well-developed connective tissue layer (Text-fig. 3, ct) between these two muscle layers. The third is oblique (Text-fig. 3, obm). The fourth is again circular (Text-fig. 3, cmi). The innermost layer of the body-wall is formed by the peritoneum (Text-fig. 3, p) which is made up of a single cell-layer, and lines the body cavity.

The alimentary canal is represented by a long coiled tube fastened to the body-wall by means of numerous stout fixing-muscles (Text-fig. 2, f). The mode of convolution of the alimentary canal seems to be generally constant. Of the alimentary canal, there may be distinguished the following eight parts: —

1) Mouth.

2) Pharynx (Text-fig. 2, ph), the first portion led from the mouth, is a large muscular sac about 15 mm. long and is attached to the body-wall by the fixing-muscles.

3) Oesophagus (Text-fig. 2, o), thick-walled muscular tube, measur-



Text-fig. 3. *Urechis unicinctus* (VON DRASCHE). Transverse section through the body-wall in the middle of the worm. c, cuticle; cmi, inner circular muscle layer; cmo, outer circular muscle layer; ct, connective tissue layer; cu, cutis; ep, epidermal layer; lm, longitudinal muscle layer; obm, oblique muscle layers; p, peritoneum. (×44).

ing about 30 mm. in length.

4) Crop (Text-fig. 2, cr), the short coiled portion.

5) Gizzard (Text-fig. 2, g), a narrow straight canal running down to the posterior end of the body-cavity. It is about 60 mm. in length.

6) Intestine (Text-fig. 2, i). It is represented by a long coiled tube, attached to the body-wall at several places, by means of fixing-muscles. The intestine is accompanied by a narrow canal called the collateral intestine (Text-fig. 2, ci) running along nearly its whole length. The collateral intestine is otherwise called "siphon", "accessory intestine" and "Nebendarm" by various authors. GREEFF thought that it was a blood vessel and said that it was to be called "Darmvene". In regard to this organ, Selenka was of the same opinion as GREEFF and thus he also used the term "blood vessel" in his

report on Gephyrea of the Challenger Expedition. The collateral intestine, at both its extremities, is transferred into the ciliated groove (Text-fig. 2, cg) which also runs along the intestine.

7) Rectum (Text-fig. 2, r), a broad and greatly extensible tube about 90 mm. long. It runs down straightly along the left side of the ventral nerve-cord (Text-fig. 2, n), and terminates in the anus at the posterior extremity of the body. A number of fixing-muscles arranged in a row fasten the rectum to the inner surface of the body-wall at the left side.

8) Anus, which is terminal in position.

There exist no blood vessels in the body proper, but an irregular sinus system is met with in the proboscis. The sinuses are narrow at first but gradually become broader and form at last very spacious cavities which directly communicate with the body cavity.

There is a single ventral nerve-cord (Text-fig. 2, n), extending from mouth to anus; it sends off many side branches on both sides which penetrate into the body-wall and thus the cord is at the same time fixed to the inner surface of the body-wall. No ganglia are seen in the ventral nerve-cord.

Situated at the posterior end of the body-cavity is a pair of anal vesicles (Text-fig. 2, av), which are often called "posterior nephridia". Each vesicle arises from the posterior region of the rectum at the ventro-lateral side. The basal one-fourth of its length is fastened to the body-wall by means of several fine fixing-muscles; while the remaining three-fourths are set free in the body-cavity. A large number of ciliated funnels are distributed on the outer wall of the anal vesicle. The function of these organs, according to EMBLETON (1900, p. 89), is excretory.

Behind the two anterior ventral hooks, there exist two pairs of segmental organs (Text-fig. 2, so), each consisting of a tube provided with two orifices at the inner end. By means of one of these orifices it communicates with the body-cavity and it also opens to the exterior by the other. Two lips (Text-fig. 2, sl) which surround the inner orifice of the segmental organ are greatly prolonged and, moreover, are spirally twisted forming 12–20 coils. They are broad at the base but taper towards the extremity and contain no lumen inside. A ciliated groove runs spirally along its whole length. The segmental organs serve as the gonoducts and the eggs and the sperms are carried to

the exterior from the body-cavity by these organs.

Localities. — This species has been reported by many authors from various localities in Japan such as: Inland Sea (WILLEMOES-SUHM, 1876, SELENKA, 1885); East coast of South Japan (DRASCHE, 1881); Tôkyô (EMBLETON, 1900); Shikoku (FISCHER, 1914); Along the Pacific coast of Japan (IKEDA, 1904); Hokkaidô (IKEDA, 1924); North Japan (OSTROUMOV, 1909).

Excluding Japan it was reported from Russia by SKORIKOV (1909) and from Amurland and De Castries Bay by FISCHER (1895).

In Mutsu Bay the species was obtained at Moura, Nonai, and Asamushi near the Marine Biological Station.

Remarks. — EMBLETON (1900, p. 80) says, showing the figure of the transverse section of the body-wall, that: — "The muscle-sheath comes next, the outermost layer is made up of circularly arranged fibres; below this is a band of longitudinal muscles, followed on the inner side by another layer of circular muscles, showing, however, a slight obliquity as compared with the outer circular layer." The specimens from Mutsu Bay show some differences in the arrangement of the muscle layers of the body-wall compared with those reported by EMBLETON: namely, in the specimens from Mutsu Bay there are found two muscular layers beneath the longitudinal muscle layer, while in those reported by EMBLETON there exists only one. I have also examined a great number of specimens collected from the following localities in Japan: — Tateyama Bay, Osaka Bay, Onomichi Bay, Hiroshima Bay and Ariake Bay. But I could not find any specimen which bears the muscular arrangement identical with that reported by EMBLETON. All the specimens from various localities in Japan above mentioned have shown the same features in the muscular arrangement as the specimens from Mutsu Bay.

In regard to the size of the body, the specimens from Mutsu Bay show exceedingly greater dimension than those reported by other authors.

Only three species are hitherto known of the genus *Urechis*: they are *U. unicinctus* (VON DRASCHE), *U. chilensis* (M. MÜLLER) and *U. caupo* FISCHER. *U. unicinctus* may be easily distinguished from the other two species by the number of the segmental organs. It bears only two pairs of these organs, while the others carry three pairs.

Genus IKEDA WHARTON.

Nephridia, provided with terminal funnels, are variable in number, and are not arranged in pairs; longitudinal muscle layer of the body-wall always lying outside of both the circular and oblique muscle layers.

2. Ikeda taenioides (IKEDA)

(Text-fig. 4)

Thalassema taenioides, IKEDA, 1904, pp. 63-64; 1907, pp. 16-47, Pl. I, Fig. 3, Pl. II, Figs. 18-22, Pl. III, Figs. 23-36, Pl. IV, Figs. 37-47.
Ikeda taenioides, WHARTON, 1913, pp. 243-270.

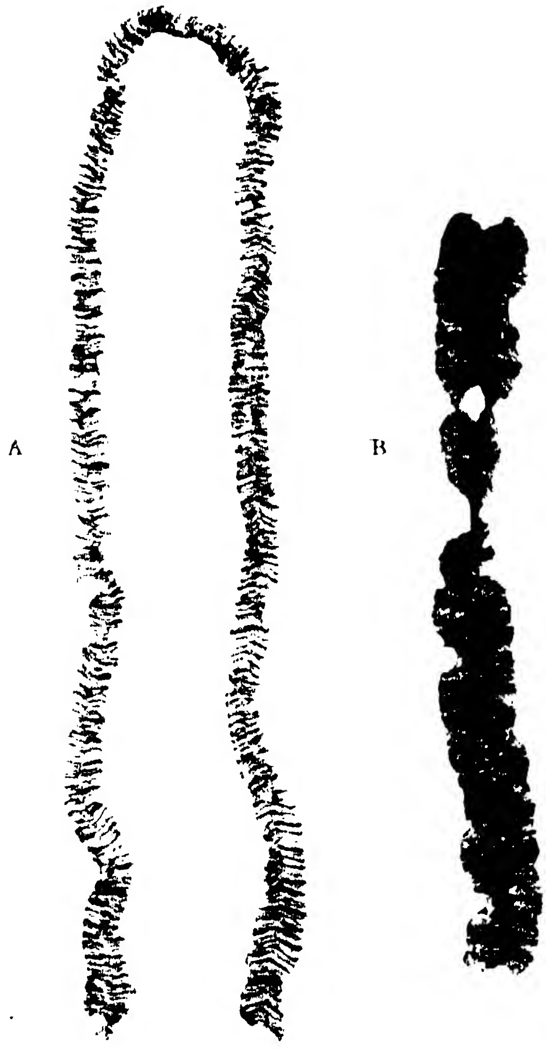
Several pieces of the proboscis were collected from the muddy-bottom of 3-6 fathoms depth off the coast of Asamushi by means of a dredge.

They are long, flat, and band-like in form, measuring up to 600 mm. long and 5-7 mm. wide when fully extended; while they become much shorter when they contract. The photograph of these two specimens is shown in Text-fig. 4.

In both external appearance and internal structure, the proboscis from Mutsu Bay closely resembles that of *Ikeda taenioides*, which was fully described by IKEDA (1907) dealing with the specimens from Sagami Bay.

The most important characters for the classification of the group of these animals are the arrangement of the nephridia and that of the muscle layers of the body-wall. From the above reason, of course, it is a hard task to define the species by means of proboscis only. But judging from the fact that no form which bears such an enormously long proboscis has been ever reported except for *Ikeda taenioides*, and also from the fact that the proboscis in question shows structural features entirely identical with that of the said species, it seems highly reasonable to assume that the proboscis is of *Ikeda taenioides*.

Localities. — Sagami Bay, Tsushima, Amakusa, Tomo, Inland Sea, Tateyama, Haneda, Japan (IKEDA, 1904); Off Asamushi (3-6 fathoms) in Mutsu Bay.



Text-fig. 4. *Ikeda taenioides* (IKEDA). Two pieces of the proboscides. a, Extended specimen; b, Contracted specimen. (Natural size).

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Contributiones ad Salicologiam Japonicam IV[1]

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(Opus acceptum 9 Mart. 1931)

Salix Lackschewitziana TOEPFFER in Österr. Bot. Zeits. LXVI. p. 402 (1916).

Syn. *Salix coerulescens* (non DÖLL) TURCZANINOW, Pl. Exsicc. ann. 1828 ex LEDEBOUR, Fl. Ross. III. p. 602 (1851) (fide LACKSCHEWITZ).— TRAUTVETTER, Incr. Fl. Phaen. Ross. III. p. 692 (1883).

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[1] Confer: I. in Tokyo Bot. Mag. XL. pp. 7–14; II. ibid. XL. pp. 633–643; III. ibid. XLII. pp. 566–576.

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var. **typica** KIMURA nov. nom.

Syn. *Salix rorida* LACKSCHEWITZ l. c. pro parte (specim. ♂ excl.). *Salix rorida* LACKSCHEWITZ var. *typica* KIMURA ined. in litt. ad R. GÖRZ Brandenburgi ann. 1930.

Bracteolae femineorum masculinorumque florum infra medium utroque margine glanduloso-crenulatae.—— Descr. typ. ♂: Arbor. *Amenta* ♂ praecocia sessilia oblongo-cylindrica densiflora ante anthesin villosissima, 3.7–4.3 cm longa 2.0–2.5 cm crassa, basi bracteofoliis 2–5 ovatis vel elliptico-ovatis sessilibus apice obtusiusculis, margine integerrimis vel glanduloso-crenulatis 4.5 × 2.5, 5.8 × 2.8 mm etc. magnis suffulta. *Bracteolae* oblongo-obovatae apice obtusissimae basin versus cuneatiusculae, infra medium utroque margine glanduloso-crenulatae, dimidia superiore parte nigrescentes inferiore pallide flavo-virides, utrinque pilis rectis albisque 1.5–3.0 mm longis villosissimae. *Glandula* una ventralis lineari-oblonga paullo obcompressa flavo-viridis. *Stamina* 2, filamentis liberis glabris ad 1.0 mm longis; antherae luteae ovato-ellipticae basi leviter obliquae 1.5 mm longae 0.9 mm latae. Ceterum ut in ♀.

HAB. HOKKAIDO.—Prov. Ishikari: Makomanai, prope Sapporo, (A. KIMURA n. 1910 ♂ fl. typus ♂ var. 7 Apr. 1930, in Herb. A. KIMURA.— A. KIMURA n. 1906 ♀ fl. 7 Apr. 1930.— A. KIMURA n.

1913 ♀ fl. 7 Apr. 1930.— A. KIMURA n. 1924 ♀ fl. 14 Apr. 1930; fol. 5 Julio 1930.— A. KIMURA n. 1907 ♂ fl. 7 Apr. 1930.— A. KIMURA n. 1908 ♂ fl. 7 Apr. 1930.— A. KIMURA n. 1909 ♂ fl. 7 Apr. 1930.— A. KIMURA n. 1911 ♂ fl. 7 Apr. 1930.— A. KIMURA n. 1912 ♂ fl. 7 Apr. 1930); Ishikiriyama, ad ripas fl. Toyohiragawa, (A. KIMURA n. 1926 ♀ fl. 15 Apr. 1930.— A. KIMURA n. 1929 ♀ fl. 15 Apr. 1930); Sapporo, ad ripas fl. Toyohiragawa, (A. KIMURA n. 649 ♀ fr. 22 Maio 1927; fol. 2 Sept. 1927.— A. KIMURA n. 1351 ♀ fl. 19 Maio 1927.— A. KIMURA n. 1364 ♀ fr. 22 Maio 1927.— A. KIMURA n. 1365 ♀ fr. 22 Maio 1927.— A. KIMURA n. 1366 ♀ fr. 22 Maio 1927.— M. TATEWAKI n. 10678 ♀ fr. 17 Maio 1928); prope Asahigawa, (A. KIMURA n. 1395 ♀ fr. 29 Maio 1927).

HONSHU.— Prov. Shinano: Kamikôchi, (A. KIMURA n. 783 ♀ fr. 1 Junio 1928; fl. 15 Maio 1929; fol. 23 Aug. 1929).

var. **roridaeformis** KIMURA nov. nom.

Syn. *Salix daphnoides* (non VILLARS) SEEMEN, Salic. Jap. p. 49 (pro parte) t. 9. fig. B (1903).

Salix rorida LACKSCHEWITZ l. c. pro parte (specim. ♀ excl.).

Salix roridaeformis NAKAI in Tokyo Bot. Mag. XXXIII. p. 5. (1919); Report Veget. Kamikôchi pp. 15, 38 (1928); in Bull. Soc. Dendrol. France n. 66, p. 14 (1928); Fl. Syl. Koreana, XVIII. p. 96, t. 13 (1930).

Salix rorida LACKSCHEWITZ var. *eglandulosa* KIMURA ined. in litt. ad R. GÖRZ Brandenburgi ann. 1930.

A praecedente aliquantum differt bracteolis femineorum masculinorumque florum basi utroque margine integris non glandulosis.— Desc. typ. ♂. Arbor. *Amenta* ♂ praecocia sessilia oblongo-cylindrica densiflora, 3.0–4.3 cm longa 1.6–2.0 cm crassa, basi bracteofoliis 2–3 ovatis vel anguste ovatis sessilibus apice obtusiusculis utrinque villosissimis margine integris 4.5×2.0, 3.8×2.0, 2.9×2.0 mm etc. magnis instructa. *Bracteolae* spatulato-oblongae apice obtusae basin versus cuneatae, margine integerrimae non glanduliferae, supera parte nigrescentes infera pallide flavo-virides circiter 3.5 mm longae 1.2 mm latae, utrinque albo-villosissimae (intus tantum basi glabriusculae). *Glandula* una ventralis oblonga apice truncata 0.7 mm longa 0.4 mm lata. *Stamina* 2, filamentis liberis glabris ad 7 mm longis; antherae luteae elliptico-ovatae 1.1 mm longae 0.8 mm. latae. *Amenta* ♀ (tantum

deflorata vidi) in plantis Kamikôchiensibus oblongo-cylindrica quam ♂ angustiora paullo curvula densiflora sessilia ad basin bracteofoliis paucis ovatis vel oblongis apice acutiusculis instructa, 3.5–5.5 cm longa 1.1–1.5 cm crassa. *Bracteolae* obovato-oblongae apice obtusissimae vel subrotundae margine integerrimae non glanduliferae, supera parte nigrescentes infera pallide flavo-virides, utrinque sericeo-villosissimae, 3.0–3.5 mm longae 1.3–1.5 mm latae. *Glandula* una ventralis fere rectangularis apice truncata 0.5 mm longa ac lata. *Ovaria* inter fructus remanentia viridia longe ovato-conica glaberrima 2.0–2.4 mm longa 0.6–1.0 mm crassa; stipitibus glabris 1.0–1.3 mm longis; stylis glabris circ. 1.5 mm longis. *Stigmata* lineari-oblonga 0.7–1.0 mm longa.

HAB. HONSHU. — Prov. Shinano: Kamikôchi, (A. KIMURA n. 1873 ♀ 24 Maio 1929; fol. 25 Aug. 1929.— A. KIMURA n. 774 ♀ fr. 7 Junio 1928; fol. 23 Aug. 1929.— A. KIMURA n. 1721 ♀ fl. 12 Maio 1928; fr. 7 Junio 1928; fol. 23 Aug. 1929.— A. KIMURA n. 1636 ♀ gemm. 7 Nov. 1927.— A. KIMURA n. 1866 ♂ fl. typus ♂ var. 15 Maio 1929 in Herb. A. KIMURA; fol. 25 Aug. 1929.— A. KIMURA n. 1638 ♂ gemm. 8 Nov. 1927.— A. KIMURA n. 1646 ♂ gemm. 7 Nov. 1927.— A. KIMURA n. 1725 ♂ fl. 14 Maio 1928).

Occurrit saepe in silvulis ripariis alpinae vallis quae japonice appellatur Kamikôchi forma inter praecedentes varietates intermedia; florum bracteolis glandulosis eglandulosisque simul in uno eodemque amento sine ordine mixtis. Crescit etiam haec in insl. Hokkaido et Sachalin, sed non vulgaris esse videtur.

Salix lepidostachys O. v. SEEMEN in ENGLER's Bot. Jahrb. XXI. (1896) Beibl. LIII. p. 51 (1896); Salic. Jap. p. 58, t. 12, fig. F—K (1903).— TOKUBUCHI in Tokyo Bot. Mag. X. p. 124 (1896).— ? LÉVEILLÉ in Bull. Acad. Intern. Géogr. Bot. XIV. pp. 207, 210 (1904). — MATSUMURA, Ind. Pl. Jap. II. 2, p. 11 (1912).— C. K. SCHNEIDER in SARGENT, Pl. Wilson. III. p. 166 (1916), pro parte.— KOMAROV, Pl. Austro-Ussurienses, p. 50 (1923).

=**Salix Miyabeana** O. v. SEEMEN in ENGLER's Bot. Jahrb. XXI. (1896) Beibl. LIII. p. 50 (1896); Salic. Jap. p. 57, t. 12, fig. A—E (1903).— TOKUBUCHI in Tokyo Bot. Mag. X. pp. 69, 125, t. 6 (1896). — MATSUMURA, Ind. Pl. Jap. II. 2, p. 12 (1912).— KOIDZUMI in Tokyo Bot. Mag. XXVII. p. 264 (1913).— C. K. SCHNEIDER in

SARGENT, Pl. Wilson. III. p. 116 (1916).—MIYABE & KUDO, Icon. Ess. For. Trees of Hokkaido, Fasc. VI. p. 63, t. 19 (1921).

NOM. JAP. Ezono-kawa-yanagi.

Salix Nakamurana KOIDZUMI in Tokyo Bot. Mag. XXVII. p. 96 (1913); in MATSUMURA, Icon. Pl. Koishikav. I. 6. p. 149, t. 75 (1913). — C. K. SCHNEIDER in SARGENT, Pl. Wilson. III. p. 135 (1916) excl. syn.—KIMURA in Tokyo Bot. Mag. XLII. p. 574 (1928) excl. var.

Syn. *Salix cyclophylla* MAKINO et NEMOTO (non O. v. SEEMEN), Cat. Jap. Pl. in Herb. Nat. Hist. Dept. Tokyo Imp. Mus. p. 309 (1914).

var. **eriocarpa** KIMURA var. nov.—Differt a typo ovariis tomentosis. —Fruticulus habitu ut in typo. *Ramuli* novelli flavo-virides glabri vel laxe villosi, annotini glaberrimi brunnei nitentesque. *Folia adulta* elliptica vel ovato-elliptica, apice rotundata basi acuta vel obtusa, margine integerrima, supra viridia subtus dilute glauca, utrinque glabra 2.6 × 1.4, 4.2 × 2.5 cm etc. magna; costa supra immersa subtus prominente, nervis primariis supra immersis subtus prominentibus utroque latere 5–10, leviter arcuatis, versus apicem folii plus minusve convergentibus. Petioli graciles glabri vel parcissime villosi ad 1.7 cm longi. *Amenta* ♀ coaetanea oblongo-cylindrica sub anthesi 2–2.7 cm longa 0.8–1.0 cm crassa. *Bracteolae* oblongae concavae apice rotundatae, utrinque villosae vel hirsutae, pallide flavo-virides superne brunnescentes vel rubicundae, fere 2.0 mm longae 0.9 mm latae. *Glandula* una ventralis flava oblonga apice truncata, interdum emarginata fere 1.0 mm longa 0.5 mm lata. *Ovaria* viridia ex ovata basi lanceolato-conica, sub anthesi 2–2.2 mm longa, 0.7–0.9 mm crassa, pilis albis curvulis tomentosa vel tomentella, stipitibus pilosis 0.7 mm longis; stylus glaber ad 1.0 mm longus. *Stigmata* flavo-viridia bifida fere 0.6 mm longa divaricata. *Capsulae* flavo-brunneae sparse pubescentes, partibus secus suturam saepe glabrescentibus.

HAB. HONSHU.—Prov. Shinano: monte Yatsugatake, (A. KIMURA n. 712, typus var. in Herb. A. KIMURA, 12 Julio 1927; 17 Sept. 1927).

Salix Reinii FRANCHET et SAVATIER, Enum. Pl. Jap. I. p. 459 (1875).—SEEMEN, Salic. Jap. p. 41, t. 6, fig. A—E (1903).— ? LÉVEILLÉ in Bull. Acad. Int. Géogr. Bot. XIV. p. 208 (1904); ibid.

XVI. p. 143 (1906).— KOIDZUMI in Tokyo Bot. Mag. XXVII. p. 91 (1913).— C. K. SCHNEIDER in SARGENT, Pl. Wilson. III. p. 127 (1916).

Syn. *Salix glabra* (non SCOPOLI), FRANCHET et SAVATIER, Enum. Pl. Jap. II. p. 503 (1879).— KAWAKAMI in Tokyo Bot. Mag. X. p. 50 (1896); ibid. XIV. p. 107 (1900); ibid. XV. p. 241 (1901).— TOKUBUCHI in Tokyo Bot. Mag. X. p. 123 (1896). — MATSUMURA, Ind. Pl. Jap. II. 2, p. 10 (1912).

var. **eriocarpa** KIMURA var. nov.— A typo ovariis undique albo-sericeis dignoscenda.— *Frutex* ramis ascendentibus, in sicco fuscis glabris. *Cataphylla* utrinque glabra ut in typo. *Folia* (adulta nondum evoluta) inferiora elliptica margine serrulata, apice obtusa vel acuta basi acuta ad rotundata, supra costa puberula excepta glabra, subtus glauca costa elevata, 20 × 10, 24 × 12 mm etc. magna; *juvenilia* utrinque (supra densius) sericea. *Amenta* ♀ anguste cylindrica usque 2.9 cm longa 0.7 cm crassa, rhachide griseo-pubescente, pedunculis usque 0.8 cm longis pubescentibus, basi saepe glabrescentibus, 3–5-foliatis, foliis parvis ceteris similibus petiolatis ellipticis utrinque acutis vel obtusis margine serrulatis basi saepissime integris supra glabris subtus glaucis costa pilosiuscula excepta glabris, minoribus 1.0 cm longis 0.5 cm latis, majoribus 1.8 cm longis et 0.8 cm latis. *Bracteolae* ovatae obtusissimae utrinque (intus densius) sericeae, fere 1.1–1.2 × 0.8–0.9 mm magnae. *Glandula* una ventralis ovata apice truncata 0.7–0.8 mm longa, basi 0.4–0.5 mm lata. *Ovaria* ovato-conica, circiter 1.8 mm longa, undique pilis albis dense sericea, stipitibus sericeis glandulam fere aequantibus, stylis glabris stipitibus paullo longioribus. *Stigmata* brevia crassa integra vel emarginata.

HAB. HONSHU.— Prov. Suruga: Subashiri, pede montis Fujisan, (A. KIMURA n. 203 typus var. in Herb. A. KIMURA, 14 Maio 1926); ibid. (T. SAWADA ♀ fl. 14 Maio 1922).— Prov. Kai: Katsuyama, in pede montis Fujisan, (B. HAYATA ♀ fl. in ripa lacus Kawaguchiko, 14 Maio 1924, in Herb. Univ. Imp. Tokyo.)— Prov. Shinano: Kawakamimura, (K. OHI n. 3 ♀ fr. 15 Maio 1930).

Salix yezoensis[1] KIMURA in Tokyo Bot. Mag. XLV. p. 28 (1931).

[1] Specimina hujus speciei antea emisi sub nomine „**Salix Gmelini** PALLAS var. **yezoensis** KIMURA" ad cl. R. GÖRZ Brandenburgi, ad usum editionis salicum exsiccatarum asiaticarum.

Syn. *Salix viminalis* (non LINNÉ) TOKUBUCHI in Tokyo Bot. Mag. X. p. 124 (1896).— SEEMEN, Salic. Jap. p. 50, t. 9, F—K (1903).— LÉVEILLÉ in Bull. Acad. Intern. Géogr. Bot. XIV. p. 209 (1904); ibid. XVI. pp. 146, 148, 151, (1906).— MATSUMURA, Ind. Pl. Jap. II. 2, p. 15 (1912).— MAKINO & NEMOTO, Cat. Jap. Pl. in Herb. Nat. Hist. Dept. Tokyo Imp. Mus. p. 311 (1914).— MIYABE & MIYAKE, Fl. Saghl. p. 428 (1915).

Salix viminalis L. var. *yezoensis* C. K. SCHNEIDER in SARGENT Pl. Wilson III. p. 158 (1916).— MIYABE & KUDO, Icon. Essent. For. Tr. Hokkaido, Fasc. VI. p. 58, t. 17, (1921).— KUDO in Jour. Coll. Agr. Hokkaido Imp. Univ. XII. 1. p. 30 (1923). — MAKINO & NEMOTO, Fl. Jap. p. 1130 (1925).

Species haec *S. viminali*[1] L. et *S. Gmelini* PALLAS affinis sed facile distinguitur a prima habitu altiore, foliis duplo vel ultra latioribus subtus pilis longioribus costaque vulgo parallelis argenteo-micantibus, ovariis sub anthesi brevioribus, stigmatibus multo brevioribus non filiformibus; etiam a secunda, cui sat similis, praecipue stigmatibus multo brevioribus 1/2.5–1/4 styli aequantibus, et speciem propriam, me judicante, efficit.— *Arbor* usque 6–13 m alta; trunco diametro ad 30 cm crasso, cortice cinereo-fusco vel fusco-brunneo longitudine irregulariter rimoso obtecto. *Ramuli* novelli pallide virides albo-sericeo-velutini; annotini rectiusculi erecto-patentes dilute olivacei vel brunneo-olivacei pilis brevibus curvulis nunc dense nunc leviter cinereo-velutini basin versus plus minusve glabrescentes. *Rami* glabrati cortice viridi- vel cinereo-brunneo. *Gemmae* amentiferae anguste ovatae vel oblongae apice obtusae straminello-brunneae superne badiae pilis cinereis sericeo-velutinae 9–10 mm longae circiter 3 mm latae; foliiferae ovatae obtusae cinereo-velutinae vel glabrescentes 5.5–8 mm longae 2–3 mm latae. *Cataphylla* sessilia lanceolato-oblonga ad linearia apice acuta vel obtusiuscula margine integerrima supra glabra vel ad costam puberula subtus albo-sericeo-villosa, 7 × 2, 9 × 2.5, 11 × 3, 13 × 3.5, 16 × 3 mm etc. magna. *Folia juvenilia* aestivatione revoluta, utrinque (subtus satis densius) sericea; *adulta* lanceolata, oblongo-lanceolata vel anguste lanceolata, apicem versus attenuato-acuminata, basi acuta vel

[1] Hic gratias ago maximas cl. R. GÖRZ Brandenburgi, quod mihi specimina Salicis viminalis liberaliter dederit.

obtusa margine integerrima leviter revoluta, supra saturate viridia glaberrima vel sub lente inaequaliter sparse puberulentia paullo nitida, subtus pilis rectis adpressis 0.5–1.6 mm longis densissimis costa plerumque parallelis argenteo-micantia, 11—20 × (1.3–)1.5—2.0(–2.8) cm magna, 6–10(–12)-plo longiora quam latiora; costa pallida supra leviter subtus valde prominente utrinque minute pubescente, vel supra tantum fere glabra; nervis primariis supra leviter impressis subtus prominulis arcuatisque, utrinsecus 20–34 a costa sub angulis 40°–70° divergentibus ante marginem plus minusve flexuosis ascendentibusque; secundariis subirregularibus; intermediis 1–3 superioribus longioribus infra elevatis angulis latioribus vel interdum paene rectis exeuntibus. Petioli breves basi paullo dilatati pubescentes supra canaliculati 8–15 mm longi. *Stipulae* oblique lineari-lanceolatae, lineares vel raro semicordatae, apice acuminatae margine integriusculae revolutae, supra convexae nunc dense nunc sparse pubescentes interdum glabratae, subtus concavae argenteo-sericeae, 3 × 1, 7 × 1.5, 12 × 2, 14 × 2, 16 × 3 mm etc. magnae, in ramulis vegetis saepe satis majores. *Amenta* ♂ praecocia ovato- ad oblongo-cylindrica apice rotundata sessilia densiflora vulgo recta 2–3.5 cm longa 0.9–1.5 cm crassa, basi bracteofoliis caducis 2–5 anguste vel raro ovato-lanceolatis supra glabris subtus dense adpresseque albido-sericeo-villosis 0.5–1.0 cm longis suffulta. *Bracteolae* oblongo-ellipticae vel obovato-oblongae apice acutae vel obtusae 2–2.3 mm longae 0.8–1.2 mm latae, basi pallide virides supera parte atro-brunnae extus margineque aequaliter intus basilari parte excepta albo-villosae; *glandula* una ventralis linearis leviter obcompressa apice truncata viridi-lutea circiter 1 mm longa 0.2–0.25 mm lata. *Stamina* 2, filamentis liberis glabris albis 5–7 mm longis; antherae luteae orbiculari-oblongae ad 1.0 mm longae. *Amenta* ♀ praecocia sessilia cylindrica recta vel paullo curvula, rhachide sericea, sub anthesi 2.5–3.5 cm longa 0.7–0.9 cm crassa, basi bracteofoliis instructa ut in ♂. *Bracteolae* forma coloreque ut in ♂, 2.0–2.5 mm longae (0.8–)1.0–1.3 mm latae extus aequaliter intus quasi supra medium margineque albo-villosae; *glandula* una ventralis linearis oblonga vel oblongo-linearis apice truncata viridi-lutea, 0.8–1.3 mm longa fere 0.2 mm lata; *ovaria* ex ovata basi breviter conica, albo-sericeo-tomentosa, sub anthesi 1.5 mm vel ultra longa 0.8 mm crassa, subsessilia vel sat brevissime stipitata; *styli* pallide flavo-virides leviter obcompressi (1.2–)1.6–2.0

mm longi ovaria longitudine superantes vel fere aequantes; *stigmata* brevia pallide viridi-flava oblonga vel ovato-oblonga vel linearia, integra bifida vel bilobulata (tum laciniis linearibus) 0.4–0.6(–0.8) mm longa (1/2–)1/2.5—1/4(–1/4.5) styli aequantia. Amenta fructifera 3.5—6 (–10) cm longa. Valvae capsulae stramineae sericeae post maturitatem falciformes extrorsum arcuatae.— Floret primo vere simul fere cum *S. sachalinensi* FR. SCHMIDT et *S. Lackschewitziana* TOEPFFER.

HAB. HOKKAIDO.— Prov. Iburi: inter Date et Sobetsu, (Y. KUDO n. 3905 st. 28 Aug. 1917).— Prov. Ishikari: ad ripas fl. Toyohiragawa, prope Sapporo, (A. KIMURA n. 1363 st. 22 Maio 1927.— A. KIMURA n. 1377 st. 24 Maio 1927); Hiragishi, prope Sapporo, (Y. KUDO n. 1441 ♀ 4 Junio 1916); Makomanai, prope Sapporo, (A. KIMURA n. 1914 ♀ fl. 7 Apr. 1930.— A. KIMURA n. 1925 ♀ fl. 14 Apr. 1930; fol. 5 Julio 1930); Sôunkei, ad ripas fl. Ishikarigawa, pede montis Nutakkamshpe, (A. KIMURA n. 1947 st. 30 Julio 1927); Asahigawa, (A. KIMURA n. 1396 ♀ fr. 29 Maio 1927); prope Yamabemura, (T. INOKUMA n. 3094 st. 4 Aug. 1930).— Prov. Hidaka: prope Urakawa, (Y. KUDO n. 434 st. 28 Aug. 1914); inter Motoura et Urakawa, (Y. KUDO n. 437 st. 27 Aug. 1914); ad ripas fl. Samani, (M. TATEWAKI n. 9269 ♀ fl. 21 Maio 1927).— Prov. Tokachi: ad ripas fl. Satsunai, prope Kôshin, (A. KIMURA n. 1920 ♂ fl. 10 Apr. 1930).— Prov. Nemuro: inter Bekkai et Shibetsu, (Y. KUDO n. 3220 st. 19 Julio 1917); inter Tobuto et Bekkai, (Y. KUDO n. 3221 st. 18 Julio 1917). — Prov. Teshio: Otoineppu, (Y. KUDO st. 8 Julio 1919); ad ripas fl. Teshiogawa, prope Otoineppu, (A. KIMURA n. 1402 ♀ fr. 30 Maio 1927); inter Otoineppu et Kamiotoineppu, (M. TATEWAKI n. 10724 ♀ fr. 2 Junio 1928); "Teshio-First-Forest", (Y. KUDO n. 4461 st. 8 Julio 1919); Wassam, (Y. KUDO n. 3220 st. 19 Julio 1917).

SACHALIN.— Prope Toyohara, (A. KIMURA n. 1406 ♀ 31 Maio 1927; fol. 27 Aug. 1927.— A. KIMURA n. 1407 ♀ 31 Maio 1927); prope Sakaehama, (A. KIMURA n. 1416 ♀ 2 Junio 1927.— A. KIMURA n. 1529 st. 14 Aug. 1927); ad ripas fl. Siruturu, (A. KIMURA n. 1420 ♀ 5 Junio 1927.— A. KIMURA n. 1423 ♀ 5 Junio 1927.— A. KIMURA n. 1531 st. 16 Aug. 1927); ad ripas fl. Nayoro, (A. KIMURA n. 1515 st. 23 Aug. 1927); ad ripas fl. Poronai, prope Siska, (A. KIMURA n. 669 ♀ 10 Junio 1927.— A. KIMURA n. 685 ♀ 10 Junio 1927; fol. 19 Aug. 1927.— A. KIMURA n. 689 st. 21 Aug. 1927); ad ripas fl.

Poronai, prope Penkehorokachiu, (A. KIMURA n. 1535 st. 19 Aug. 1927.—A. KIMURA n. 1537 st. 19 Aug. 1927); Pilewo, penins. Schmidt., (Y. KUDO 24 Aug. 1923).

NOM. JAP. Kinu-yanagi.

var. **angustifolia** KIMURA var. nov.—*Folia* adulta lanceolato-linearia apice attenuato-acuminata, basi anguste acuta, margine integerrima plus minusve revoluta, supra costa sub lente minutissime puberula excepta glabra saturate viridia leviter impressi-nervata, subtus pilis densis adpressis costaque parallelis circiter 0.5–0.7 mm longis argenteo-sericea, 11 × 0.9—14 × 1.3 cm magna, costa pallida subtus prominente minutissime puberula vel glabrescente; nervis primariis leviter arcuato-ascendentibus, prope marginem plus minusve flexuosis, a costa fere sub angulis 40°–60° divergentibus supra planiusculis vel leviter impressis, infra elevatis utroque latere 28–34, intermediis 1–2 primariis fere parallelis vel angulis latioribus divergentibus.

HAB. SACHALIN.—Siska, (A. KIMURA n. 1541 st. typus var. in Herb. A. KIMURA, 21 Aug. 1927); ad ripas fl. inter Onory et Rikowskoie (Y. KUDO st 2. Aug. 1922).

NOM. JAP. Hosoba-kinu-yanagi.

Salix kamikotica KIMURA sp. nov.

Arbor excelsa ad 20 m alta; trunco erecto diametro 32 cm crasso, cortice fuscescenti-cinereo longitudine irregulariter rimoso obtecto. *Ramuli* hornotini in aestate virides paullo nitentes glaberrimi, annotini hieme et vere flavo- vel rufo-brunnei lucidi glaberrimi circiter 2–3 mm crassi; rami cinerascentes. *Gemmae* amentiferae foliiferaeque aequiformes oblongo-ovatae apice anguste acutae intus convexiusculae ramulo applicatae, dorso convexae rufo-brunneae glaberrimae 4.0–7.0 mm longae, 1.8–2.5 mm latae; perula gemmae una coriacea ventrali latere marginibus liberis imbricatis. *Cataphylla* sterilium ramulorum sessilia pallide flavo-viridia prima(=infima) ovalia ad late elliptica apice rotundato-acuta vel acuta, utrinque glabra vel subtus tantum sparse sericea, margine integra ciliata, 8–11 mm longa, 4.5–6(–8) mm lata; secunda elliptico-obovata vel elliptica, apice late acuta, basi cuneatiuscula, supra glabra subtus sparse sericea vel glabra, 9–16 mm longa, 4–5(–7) mm lata; superiora majora obovato-oblonga vel oblongo-oblanceolata. *Folia adulta* chartaceo-coriacea oblongo-lanceolata vel ob-

longa, apice longiuscule attenuato-acuminata vel acuto-acuminata basi acuta ad obtusissima, margine (praeter apicem basimque fere integram) subargute crenato-serrulata, dentibus apice incurvulis minute mucronulatis in medio folii circiter 4–5 pro 1 cm, minora 5.5×1.8, 8.2×2.2 cm etc., majora 9.0×2.6, 10.5×3.0, 11.2×3.0 cm etc. magna, supra saturate viridia lucida subtus glauca utrinque glaberrima; costa supra fere plana minutissime pubescente, subtus valde prominente glabra pallida; nervis primariis utrinsecus 15–19 supra fere planis subtus distincte elevatis leviter arcuatis ante marginem flexuosis ascendentibus a costa sub 50°–70° divergentibus; secundariis irregularibus infra leviter elevatis; intermediis 1–2 primariis parallelis vel angulis latioribus divergentibus. Petioli supra canaliculati pubescentes subtus convexi 1.7–2.1 cm longi. *Stipulae* oblique ovatae vel fere semiorbiculares apice acutae vel subacuminatae margine (interiore obsolete) mucronulato-denticulatae infra glaucae, in ramulis normalibus 2.4–4 mm longae 1.2–2 mm latae, in vegetis sat majores 8 mm longae 4.5 mm latae. *Amenta* ♂ coaetanea foliato-pedunculata pendula anguste cylindrica ad 8.0 cm longa 0.9–1.2 cm crassa, rhachidibus gracilibus flavo-viridibus parce pilosis per totam longitudinem visibilibus; pedunculis 0.4–1.9 cm longis, foliis parvis 3–9, quorum infimis 2 caducissimis sterilium ramulorum cataphyllis aequalibus, superioribus majoribus ellipticis vel lanceolato-ellipticis vel lanceolato-oblongis vel fere lanceolatis apice acutis vel acuminato-acutis basi obtusissimis, supra viridibus interdum partim dilute glaucinis, subtus glaucis, integerrimis raro sursum serrulatis, 18–36(–43) mm longis 8–12(–15) mm latis, supremis minoribus angustioribusque. *Bracteolae* spatulato-oblongae apice irregulariter undulato-rotundatae basi cuneatae supera parte rubicundae infera pallide flavo-virides, ad 3.7 mm longae 1.5–1.6 mm latae, margine ciliatae. *Stamina* 5, filamentis liberis glabris 3.5–4.0 mm longis; antherae luteae ovales. *Glandula* una dorsalis interdum deest obovato-oblonga lutea apice truncato-rotundata 0.4 mm longa. Planta ♀ nobis incognita.

HAB. HONSHU.—Prov. Shinano: Kamikôchi, (A. KIMURA n. 782 ♂ fl. typus 16 Maio 1930 in Herb. A. KIMURA; fl. 31 Maio 1928; fl. 1 Junio 1928; gemm. 2 Nov. 1928; st. 24 Maio 1929; fol. 25 Aug. 1929; fl. 11 Maio 1930).

Salix sendaica KIMURA sp. nov.

Frutex ad 3 m altus, *ramulis* ascendentibus teretibus in hieme et vere badiis vel badio-viridibus in sicco atro-badiis, glabris vel superne tantum pubescentibus nitidulis superne circiter 3 mm inferne 8 mm crassis; *ramis* ascendentibus cinereo-viridibus; ligno nudo vibicibus instructo. *Gemmae* glabrae rufo-castaneae nitentes latere biangulatae, foliiferae ovatae apice obtusae 6×3—8×4 mm magnae, amentiferae ovatae apicem versus angustatae et subrostratae ad summum obtusae 9-12 mm longae 5-6 mm latae. *Cataphylla* sessilia elliptica ad elliptico-oblonga utrinque obtusa vel obtusissima, margine integra, supra glabra, infra villosissima 6-12 mm longa 3-5 mm lata, superiora majora. *Folia juvenilia* convoluta utrinque dense sericeo-tomentosa; *adulta* chartaceo-coriacea, in petiolo usque ad 1.9 cm longo semitereti pubescente vel infra glabrescente, elliptico-oblonga apice acuta vel acuminato-acuta basi rotundata, margine undulatim crenato- vel eroso-denticulata, dentibus semper mucronulatis interdum satis obsoletis subintegra, supra glabra saturate viridia nitidula valde rugosa, subtus glaucina pilis curvulis sericeo-pubescentia vel tomentella vel praeter costam nervosque glabrescentia, 11-14 cm longa 3.7-5.4 cm lata; costa supra leviter elevata minutissime pubescente demum glabrescente, subtus vehementer prominente sericeo-tomentella; nervis primariis utrinque 12-14 supra glabris immersis infra prominentibus sericeo-tomentellis arcuato-ascendentibus a costa sub angulis 50°-75° proficiscentibus; secundariis supra immersis infra elevatis crebris subregularibus; intermediis 2-3. *Stipulae* oblique ovatae vel semicordatae acutae denticulatae utrinque glabrae vel subtus pubescentes, supra virides subtus glaucinae 7-12 mm longae 4-7 mm latae. *Amenta* ♀ praecocia anguste cylindrica erecto-patentia submatura 4-7 cm longa 1-1.2 cm crassa, rhachidibus visibilibus villoso-sericeis, pedunculis brevibus ad 6 mm longis cataphyllis 4-5 forma magnitudineque iis sterilium ramulorum simillimis instructis. *Bracteolae* oblongae vel elliptico-oblongae apice obtuse acutae supera parte brunneae ceterum pallidae utrinque pilis albis villosae 1.0-1.4 mm longae 0.6 mm latae: *Glandula* una ventralis fere rectangularis 0.5-0.7 mm longa 0.4-0.5 mm lata. *Ovaria* viridia lucida partim saepe brunnescentia glaberrima (in typo) vel parce puberula ex ovata basi longe conica submatura 4.0-4.5 mm longa, pedicellis 1.5-1.8 mm longis glabris, stylis brevibus 0.5 mm longis. *Stigmata* parva ovata et emar-

ginata vel bilobulata 0.25–0.4 mm longa. Ovula 6.

HAB. HONSHU.— Prov. Rikuzen: colle Mukoyama, Sendai, (A. KIMURA n. 809 ♀ fl. typus 28 Apr. 1929 in Herb. A. KIMURA; fol. 8 Nov. 1929.— A. KIMURA n. 810 ♀ fl. 28 Apr. 1929; fol. 8 Nov. 1929).

NOM. JAP. Sendai-yanagi.

var. **eriocarpa** KIMURA var. nov.

A typo ovariis sericeo-tomentosis recedit.— *Bracteolae* oblongae vel elliptico-oblongae vel ellipticae apice obtuse acutae superne brunnescentes inferne pallidae utrinque albo-villosae, 1.1–1.5 mm longae 0.6–0.7 mm latae. *Glandula* una ventralis fere quadrangula 0.5–0.6 mm longa 0.4–0.5 mm lata. *Ovaria* submatura ex ovata basi longe conica undique albo-sericeo-tomentosa 4.5–5.0 mm longa; pedicellis sericeis 1.5 mm longis; stylis glabris 0.5 mm longis. *Stigmata* parva bilobulata, lobulis oblongis 0.3–0.4 mm longis. Ceterum ut in typo.

HAB. HONSHU.— Prov. Rikuzen: colle Mukoyama, Sendai, (A. KIMURA n. 807 fl. ♀ typus var. 28 Apr. 1929 in Herb. A. KIMURA; fol. 8 Nov. 1929.— A. KIMURA n. 1949 fl. ♀ 3 Maio 1930); Kagitori, (A. KIMURA n. 1863 fl. ♀ 29 Apr. 1929).— Prov. Rikuchu: frutex 2 m alt., Takisawamura-Shinoki, (Y. FUKUTA n. 20 fl. ♀ 30 Apr. 1929; fol. 31 Julio 1929).

On the Morphology and Physiology of *Fomes applanatus* (Fr.) GILL. and its Allies.

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(With Pls. IV–VII and I text-figure.)

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CONTENTS.

I. INTRODUCTION.

Fomes applanatus is probably one of the most widely distributed bracket fungi and grows as well on dead wood as on living trunks of various species of deciduous forest trees. The occurence of this

fungus in this country has been reported by various authors. In the identification of their specimens they have laid stress on the outer features, especially on the characteristics of the pileus-surface, but little attention has been paid to the character of the tube layers.

Fomes vegetus is a species allied to the former and is also found in this country. It is treated as a distinct species by some biologists and as a synonym of *Fomes applanatus* by others.

As such is the case, it is worth while to settle the exact taxonomic position of these fungi, and to that purpose a study on their morphology and phygiology in this connection was made. In this paper is reported the results of the study on the taxonomic position of three forms — original *Fomes vegetus*, a form newly identified as differentiated from the former, and *Fomes applanatus*.

II. MATERIALS.

This investigation has been done with 30 specimens of fungi taken from the following hosts: *Abies sacchalinensis* MAST., *Acer pictum* THUNB., *Alnus alnobetula* HARTIG. var. *fruticosa* WINK., *Betula japonica* SIEB., *Carpinus Tschonoskii* MAXIM., *Celtis sinensis* PERS. var. *japonica* NAKAI, *Diospyros Kaki* THUNB., *Fagus japonica* MAXIM., *Ligustrum ovalifolium* MASSK., *Machilus Tunbergii* SIEB. et ZUCC., *Micromeles alnifolia* FOEH., *Pasaniopsis Sieboldi* KUDÔ, *Prunus Itosakura* SIEB., *Prunus Mume* SIEB. et ZUCC., *Quercus grosseserrata* BL. *Quercus stenophylla* MAKINO, *Salix Urbaniana* SEEM., *Tilia japonica* SIMK. and *Ulmus japonica* SARG.

In the outer features, these specimens exactly correspond with *Fomes applanatus* described by PERSOON[54], FRIES[22, 23], GILLÉT[25], BERKELEY[6], COOKE[10], etc. However, it is noticed that there are three types among them which can be classified by the differences in the arrangement of the tube layers.

The first type is a form with the context tissue layer interposed between each annual tube layer, and apparently it is a typical form of *Fomes vagetus* (FR.) COOKE. The second type is a form with a white mycelial layer interposed between the annual tube layers; seemingly it is newly differentiated from *Fomes vegetus* (FR.) COOKE. The third type is a form with no context tissue nor white mycelial

layer interposed between the strata of tubes, though the boundary of each annual tube layer is faintly visible, so that it is identical with *Fomes applanatus* (FR.) GILLÉT.

From the 30 specimens collected the three types above metioned were separated and used in the experiments.

III. MORPHOLOGICAL STUDIES.

A. General Characteristics of the Sporophores.

Between any two of the three types above mentioned, hardly any differences can be recognized in the outer features of the sporophores, unless the examination is extended to their stratose tube layers.

The sporophores are horizontal, flattened semicircular or kidney-shaped, sessil or sometimes with an obscure short lateral stalk, concentrically zoned, and with obtuse margin. The crusts are corneous, cracked and tubercular, especially in the older and larger specimens. The colour of both the upper and under surfaces of the sporophore are variable. The upper surface is ferruginous at the early stage on account of the covering with conidia, and later turns to grayish-brown, gray or white. The under surface is at first white in colour, then turns to yellowish, becoming pink by exposure to rain, but quickly changes to a dark-brown when bruised. The pores are round and minute. The context tissue is at first punky, and later becomes hard and thin. The context tissue and tube layers are concolorous, commonly ferruginous, with various shades according to the host.

B. General Characteristics of the Spores.

The discharging period of the spores of these species is from the first of July to the end of September. Notwithstanding that *Fomes applanatus* has been studied and reported by many authors, their descriptions of the spores do not exactly coincide with our observation.

1) *Spore shape.*

As to the spore shape of *Fomes applanatus*, some authors (SCHROETER[66)], KARSTEN[8)], MIGULA[39)], BOSE[8)], etc.) reported that the spores were ovoid, while others (PATOUILLARD[53)], BRESADOLA[9)], MURRILL[41—46)], LLOYD[33—35)], OVERHOLTS[52)], STEVENS[71)], REA[56)], etc.) wrote that they were ovoid, obovoid or broadly ellipsoidal and truncate at the base. ATKINSON in his two papers[2,3)] persisted in an opinion opposed to the

view of many mycologists, that the spores are attached to the sterigma with the hyaline attenuate end. He stated: "the spores are ovoid but they are not truncate at the base. They are broader and round at the base, narrowed towards the apex or distal end, where they are usually seen to be in a 'truncate' condition. The hyaline wall at the apex is much thickened and, I judge, at sometime in the developement of the spore, forms a broadly conic apex of the spore which collapses because of its more or less delicate condition, and leaves the apex in a 'truncate' condition. — They are slightly inequilateral, i. e. they are more strongly convex on one side than on the other. They are attached to the sterigma by the side of the broad end opposite the more convex side of the spore". In another paper he also wrote as to the attaching place of the spore: "the place where the spore was attached to the sterigma is at the side of the broad rounded end opposite the convex side. Sometimes a minute angle can be seen here where the sterigma was attached." WHITE,[74] BULLER[13] and COLEMAN[15] agreed with ATKINSON's observation.

The writer's observations on the spores of our three related species show that the spores are practically of the same shape and always truncate at the base as according to the statements of a large number of mycologists, except ATKINSON, BULLER and others. Mature spores are brown to dark-brown in colour, obovate, obtuse at the apex, attenuate and truncate at the base. Yet, fresh emissive spores are usually obovate in shape and always hyaline at the base, but never "more or less inequilateral, that is, one side is more convex than the other" as in the statement of ATKINSON. It is likely that ATKINSON has observed and described only shrunken spores. At the apex of the spore, there is a small germ pore which was erroneously described as an attaching place to the sterigma by some authors.

2) *Structure of the spore wall.*

As to the markings of the spore-wall of *Fomes applanatus*, there are three divergent opinions; i. e., i) verrucose or echinulate, ii) smooth or slightly roughend, and iii) smooth. The first opinion was supported by SACCARDO[60,61], KARSTEN[3], PATEULLARD[53], LLOYD[35], HARD[28], REA[58], and others; the second by BRESADOLA[9], MURRILL[41–46], STEVENS[71] and others; and the third by SCHROETER[66], PATEULLARD[53], BRESADOLA[10], ATKINSON[2,3], MIGULA[39], AMES[1], WHITE[74], BULLER[13] and others.

To settle this question, a careful examination of the spore markings of the three species in question was made by staining the spores in the following manner. A stock solution, the mixture of 5 parts of 0.5 per-cent neutral-red water solution with 10 parts of 0.5 per-cent methyl-green water solution, was diluted with water to 25 times and allowed to act on the spore about an hour, then the spores were observed under microscope. By this treatment, the writer succeeded in demonstrating that the wall of mature spores is decidedly warty, as its photomicrographs are reproduced in Figs. 8 and 10 in Plate IV.

3) *Spore size.*

The data of spore size of *Fomes applanatus* and *Fomes vegetus*, hitherto described by many authors, are gathered in Table I, (a) and (b) respectively, which show large variation in this respect. The results of my observation on the spore sizes of various samples above mentioned are shown in Table II. We can notice from Table II that on the average, the spore size of the first type is the smallest of the three and that of the third type is the largest; although the spore size of the second type is a little larger than the first type, there is no such difference as between the third type and the others. In connection with this study, an examination was also made on American specimens of *Fomes applanatus* sent from WEIR and GRANT and preserved in the herbarium of the Biological Institute, Tôhoku Imperial University. The examination showed that they belong to the first type in respect to the characteristics of their tube layer and spore size.

In view of the great significance of spore size in the identification of types, it may, from the data in Table I, be said that the first type in the sense of my classification, i. e. *Fomes vegetus*, was erroneously included under the name of so-called *Fomes applanatus* in the former studies.

TABLE I, (a). The spore size of so-called *Fomes applanatus*.

Authors	Spore size (μ)	Date
ATKINSON	6–9×4.5–5.5 (European specimen) 6–8×4–5.5 (American specimen)	1908 (3)
BOSE	6.6×3.3	1920 (8)

Authors	Spore size (μ)	Date
BRESADOLA	7–9×5 8–10×5–6	1897 (9) 1918 (3)
BOURDOT et GALZIN	8–12×5–8	1828 (7)
KARSTEN	6–8×5–6	1889 (3)
KILLERMAN	6–7×4–5	1918 (32)
REA	9–13×6–8	1922 (58)
LLOYD	10×6	1915 (35)
MIGULA	6.5–7×4–5	1910 (39)
MURRILL	8–9×5 7–8×5–6 7–8×5–6	1908 (41) 1908 (42) 1914–'15 (43–46)
NEUMAN	6–7×?	1914 (49)
PATEUILLARD	8–9×5 11–12×7–8	1889 (53) 1889 (53)
SACCARDO	8–9×5 11–12×7–8	1916 (61) 1916 (61)
SCHROETER	6.5–7×4–5	1888 (68)
STEVENS	7–8×5–6	1921 (71)
WHITE	7–9×5–6	1920 (74)

TABLE I, (b). The spore size of so-called *Fomes vegetus*.

Authors	Spore size	Date
SACCARDO	? ×2–3 8–10×5–6	1888 (60) 1916 (61)
PATOUILLARD	7–9×5–6	1889 (53)

TABLE II. Showing the spore-measurement of *Fomes applanatus* and its allies determined by the writer.

		Host plant	Spore size (μ) length	Spore size (μ) width
Type I.	1.	*Acer pictum* TUNB.	7.85±0.025	5.61±0.020
	2.	*Alnus alnobetula* HART. *var. fruticosa* WINKL.	8.00±0.030	5.35±0.019
	3.	*Ulmus japonica* SARG.	7.43±0.020	5.19±0.019
	4.	*Fraxinus mandshurica* RUPR.	7.66±0.025	5.59±0.020
	5.	*Fagus japonica* MAXIM.	7.49±0.019	5.09±0.015
	6.	*Micromeles alnifolia* KOEH.	7.88±0.027	5.32±0.019

		Host plant	Spore size (μ) length	width
	7.	*Quercus grosseserrata* BL.	7.99±0.026	5.33±0.020
	8.	,, ,, ,,	7.80±0.021	5.26±0.017
	9.	,, ,, ,,	7.54±0.018	5.30±0.018
	10.	*Salix Urbaniane* SEEM.	8.02±0.029	5.32±0.020
	11.	*Tilia japonica* SIMK.	7.47±0.017	5.12±0.012
	12.	,, ,, ,,	8.50±0.029	5.54±0.022
	13.	*Betula japonica* SIEB.	8.25±0.027	5.27±0.018
	14.	,, ,, ,,	7.34±0.021	5.56±0.020
	Average		*7.80±0.024*	*5.34±0.019*
	American specimen, sent from GRANT		7.95±0.028	5.60±0.022
	American specimen, sent from WEIR		8.10±0.029	5.32±0.021
Type II.	15.	*Quercus grosseserrata* BL.	*8.24±0.030*	*5.17±0.020*
Type III.	16.	*Abies sachalinensis* MAST.	8.32±0.031	6.33±0.020
	17.	*Carpinus Tschonoskii* MAXIM.	9.41±0.039	5.79±0.028
	18.	*Machilus Tunbergii* SIEB. et ZUCC.	9.21±0.032	6.05±0.020
	19.	*Celtis sinensis* PERS. var. *japonica* NAKAI.	8.57±0.020	5.78±0.023
	20.	*Pasaniopsis Sieboldi* KUDÔ.	9.48±0.030	6.13±0.035
	21.	*Diospyros Kaki* THUNB.	9.86±0.029	5.97±0.017
	22.	*Prunus Mume* SIEB. et ZUCC.	9.91±0.043	5.81±0.028
	23.	,, ,, ,, ,,	9.33±0.034	5.70±0.025
	24.	*Prunus Itosakura* SIEB.	8.50±0.029	5.51±0.027
	25.	,, ,, ,,	9.84±0.038	6.10±0.025
	26.	,, ,, ,,	8.91±0.028	5.82±0.025
	27.	,, ,, ,,	8.72±0.020	5.79±0.020
	28.	*Pasaniopsis Sieboldi* KUDÔ.	8.51±0.026	5.67±0.021
	29.	*Quercus stenophylla* MAKINO.	8.32±0.028	5.79±0.040
	30.	*Ligustrum ovalifolium* HASSK.	8.46±0.025	6.01±0.017
	Average		*9.09±0.030*	*5.88±0.025*

From the foregoing investigation, it may be said that so far as outer features are concerned, no distinction can be drawn among the three types in question. If, however, the specimens are two or more years old, they may be distinguished from each other by the structure

of the inner tube layers. Moreover the spore sizes of the first and third type are quite distinct from each other.

From these differences it may be justified to consider the first as a distinct species from the third type. Evidences revealed so far may allow one also to place the second type as a variety of the first type, *Fomes vegetus*.

IV. PHYSIOLOGICAL STUDIES.

A. Source of Cultures.

The physiological studies were undertaken to determine the relationship of the fungi in question, and the specimens Nos. 3 and 12 (type I), No. 15 (type II) and Nos. 27, 29 and 30 (type III) were used for this purpose. In order to secure pure cultures of these fungi, a method was employed which may be designated as the tissue method.

A set of test tubes with a plum twig in each was previously prepared by sterilizing them in an autoclave. After cutting the fresh sporophores, small pieces of tissue or tubes were gouged out from the interior by a sterilized scalpel, and each was directly transferred to a piece of plum twig in a test tube and held in an incubator at 25°C. After a week of incubation, the characteristic white aerial mycelium was produced on the twig; the aerial mycelium was inoculated to the plum twigs sterilized in the ERLENMEYER flasks and these were preserved as stock cultures during the experiment.

B. Characteristics of the Mycelium on the Plate Cultures.

1) *Culture media.*

Four kinds of solid media were prepared for this experiment in the following ways:

a) THAXTER's glucose-potato hard agar.[62]

Two hundred grams of sliced potato in one litre of distilled water were cooked for an hour in a KOCH steam sterilizer at 100°C. The potato water strained off was restored to a litre. Then 20 grams of glucose and 30 grams of agar were added and disolved. About 15 c.c. of this mixture were filled into each tube and autoclaved for 30 minutes at 110-115°C.

b) Glucose-carrot hard agar.

This medium was prepared in the same manner as the above, except for using carrots instead of potatoes.

c) Glucose-onion hard agar.

The preparation of this medium was the same as above.

d) Apricot juice agar.

Two hundred grams of seedless dried apricot were steeped in 500 c.c. of distilled water for 24 hours. The decoction strained off was restored to one half of a litre. Then 50 grams of agar were melted in 500 c.c. of distilled water, filtered through cloth and added to the above, about 15 c.c. of the mixture were tubed and sterilized at 100°C for 30 minutes in a KOCH steam sterilizer.

2) *Growth characteristics on the solid media.*

Five sterilized PETRI dishes with media above mentioned were prepared for each fungus and after the inoculation they were incubated at 25°C. for a week. At the end of this period the mycelial growths were observed and recorded. The results of the observation are given in Table III and the actual features of growth are reproduced in photographs, Plates V–VI.

TABLE III. Showing the characteristics of the mycelia on the solid agars.

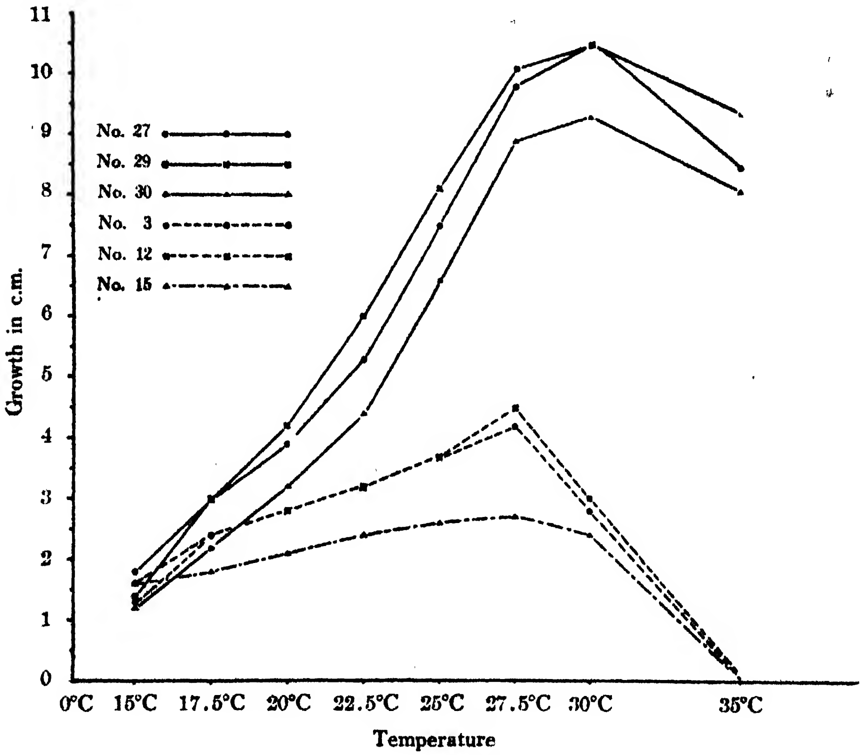
Types	Specimen	Kinds of solid media.			
		THAXTER's glucose-potato hard agar.	Glucose-carrot hard agar.	Glucose-onion hard agar.	Apricot juice agar.
I	No. 3	fluffy	more or less fluffy, especially at the periphery	perfectly creeping	densely cottony
	No. 12	more or less fluffy, especially at the periphery	ditto	ditto	ditto
II	No. 15	perfectly creeping	perfectly creeping	ditto	ditto
III	No. 27	densely cottony	densely cottony	densely cottony	ditto
	No. 29	ditto	ditto	ditto	ditto
	No. 30	ditto	ditto	ditto	ditto

From the above table, it can be noticed that the characters of the mycelium of type III are always similar in spite of the difference of solid media while those of types I and II are somewhat different. As a whole, however, it may be justified to say, that type II in its mycelial characteristics is more closely related to type I than to type III.

3) *Growth characteristics at various temperatures.*

The next point is to see the rate of growth of each species under different temperatures. For this purpose, THAXTER's glucose-potato hard agar was used as the culture medium. The organisms were

cultured in 5 PETRI-dishes for each series and the rate of their growth was measured by mycelial mass. The numericals in the following tables are the averages of three or four experiments each.



Text-fig. 1. The growth of mycelial masses after the incubation at various temperatures for one week.

The optimum temperature for the mycelial growth of types I and II is 27.5°C. and that of type III 30°C. The mycelial growth of types I and II is practically checked at 35°C., while that of type III proceeds so far, that it is hardly checked in the culture even at 35°C. These relations are also shown in Text-fig. 1.

TABLE IV. The diameter of mycelial masses at 15°C. (in c. m.)

Types	Specimen	Days						
		1	2	3	4	5	6	7
I	No. 3	—	0.40	0.64	0.90	1.13	1.33	1.57
	No. 12	—	0.30	0.50	0.70	0.90	1.10	1.30
II	No. 15	—	0.40	0.70	0.90	1.20	1.40	1.60
III	No. 27	—	0.40	0.66	0.86	1.16	1.46	1.78
	No. 29	—	—	—	0.56	0.82	1.10	1.40
	No. 30	—	—	—	0.62	0.82	1.02	1.23

TABLE V. The diameter of mycelial masses at 17.5°C. (in c. m.)

Types	Specimen	Days						
		1	2	3	4	5	6	7
I	No. 3	—	0.40	0.57	1.07	1.47	1.93	2.40
	No. 12	—	0.30	0.60	1.00	1.40	1.80	2.15
II	No. 15	—	0.47	0.77	1.07	1.33	1.60	1.80
III	No. 27	—	0.33	0.60	1.20	1.87	2.53	3.00
	No. 29	—	0.33	0.60	1.13	1.73	2.43	3.00
	No. 30	—	0.30	0.50	0.90	1.40	1.80	2.20

TABLE VI. The diameter of mycelial masses at 20°C. (in c. m.)

Types	Specimen	Days						
		1	2	3	4	5	6	7
I	No. 3	—	0.45	0.90	1.25	1.65	2.35	2.75
	No. 12	—	0.64	1.04	1.32	1.72	2.28	2.83
II	No. 15	—	0.56	0.78	1.04	1.34	1.58	2.06
III	No. 27	—	0.48	1.08	1.66	2.54	3.20	3.86
	No. 29	—	0.40	0.90	1.50	2.30	3.20	4.20
	No. 30	—	0.50	0.94	1.51	2.08	2.60	3.24

TABLE VII. The diameter of mycelial masses at 22.5°C. (in c. m.)

Types	Specimen	Days						
		1	2	3	4	5	6	7
I	No. 3	—	0.70	1.05	1.45	1.85	2.40	[illegible].15
	No. 12	—	0.80	1.20	1.60	2.20	2.70	3.20
II	No. 15	—	0.70	1.06	1.40	1.80	2.10	2.40
III	No. 27	—	1.30	2.10	3.00	3.70	4.50	5.30
	No. 29	—	1.30	2.10	3.12	4.04	5.04	6.04
	No. 30	—	0.97	1.25	2.28	3.00	3.68	4.35

TABLE VIII. The diameter of mycelial masses at 25°C. (in c. m.)

Types	Specimen	Days						
		1	2	3	4	5	6	7
I	No. 3	—	0.43	0.88	1.45	2.15	2.80	3.74
	No. 12	—	0.47	0.94	1.36	1.96	2.70	3.70
II	No. 15	—	0.63	0.93	1.23	1.58	1.98	2.55
III	No. 27	—	1.36	2.30	3.43	4.43	5.93	7.53
	No. 29	—	1.43	2.63	3.73	5.15	6.63	8.13
	No. 30	—	1.29	2.25	3.35	4.40	5.47	6.60

TABLE IX. The diameter of mycelial masses at 27.5°C. (in c. m.)

Types	Specimen	Days						
		1	2	3	4	5	6	7
I	No. 3	—	0.50	0.90	1.40	2.00	2.90	4.20
	No. 12	—	0.60	1.12	1.44	2.04	3.10	4.54
II	No. 15	—	0.60	1.10	1.40	1.80	2.30	2.70
III	No. 27	—	1.60	3.15	4.70	6.40	8.10	9.73
	No. 29	—	1.12	2.68	4.18	6.06	8.08	10.08
	No. 30	—	1.08	2.50	3.84	5.42	7.14	8.90

TABLE X. The diameter of mycelial masses at 30°C. (in c.m.)

Types	Specimen	Days						
		1	2	3	4	5	6	7
I	No. 3	—	0.60	0.75	1.25	1.83	2.28	2.80
	No. 12	—	—	0.55	0.85	1.35	2.15	2.98
II	No. 15	—	0.63	0.98	1.33	1.63	2.01	2.38
III	No. 27	—	0.95	2.18	3.63	5.75	8.10	10.50
	No. 29	—	1.40	2.60	4.20	6.30	8.40	10.50
	No. 30	—	1.00	2.11	3.30	4.93	7.08	9.32

TABLE XI. The diameter of mycelial masses at 35°C. (in c.m.)

Types	Specimen	Days						
		1	2	3	4	5	6	7
I	No. 3	Mycelial growth ceased						
	No. 12	Ditto						
II	No. 15	Ditto						
III	No. 27	—	1.33	2.13	3.15	4.60	6.33	8.53
	No. 29	—	1.03	2.37	3.37	5.67	7.23	9.40
	No. 30	—	1.95	3.18	4.08	5.23	6.65	8.08

4) *Mixed culture.*

The phenomenon of aversion in the mixed culture of two or more different fungi was applied to the classification of closely related species by many authors. To take this phenomenon into consideration, THAXTER's glucose-potato hard agar plates were prepared, and the following combinations of inocula were set up and incubated at 25°C.

The results of culture for one week are shown in the accompanying Plates VI and VII. As may be seen in Plate VI, there was no inhibiting effect in the mixed culture of two inocula from the same specimen (Figs. 10–15); the mycelia grew into each other, showing

I	II	III
No. 3 — No. 3	No. 3 — No. 12	No. 3 — No. 27
No. 12 — No. 12	No. 12 — No. 15	No. 12 — No. 27
No. 15 — No. 15	No. 15 — No. 3	No. 15 — No. 27
No. 27 — No. 27	No. 27 — No. 29	No. 3 — No. 29
No. 29 — No. 29	No. 29 — No. 30	No. 12 — No. 29
No. 30 — No. 30	No. 30 — No. 27	No. 15 — No. 29
		No. 3 — No. 30
		No. 12 — No. 30
		No. 15 — No. 30

a uniform mat on the surface of the plate agar just as in the culture of a single inoculum. When two inocula from different types were cultivated on the medium (Plate VII), the aversion of mycelial growth was always found between them. The same phenomenon was, however, found to be true even in the mixed cultures of the different specimens of the same type. Hence we are not able to get any criterion by which to distinguish the one from the other in this case. So it is very probable that this phenomenon may be realized by the deficiency of nutritive materials or by the change of pH value in the medium, without any special relation to the difference of species, as SCHMIDT[61] in the study of mycelial growth of Phycomycetes also concluded. Only it is noticed that when the mycelia from any specimen of the type III came in contact with any of other types an amber brown line appeared at the line of contact.

C) Growth Characteristics in the Liquid Media.

1) *General aspect of mycelial growth in the liquid media.*

It was well demonstrated by ZELLER[77] that many wood destroying fungi made little or no growth in liquid media, and he stated that

CZAPEK's solution (pH 3.21)		RICHARD's solution (pH 3.37)	
KAHLBAUM's KH_2PO_4	1.3616	KAHLBAUM's KH_2PO_4	0.5446
,, KCl	0.3728	,, KNO_3	4.0444
MERCK's $NaNO_3$	2.1253	,, NH_4NO_3	8.0050
,, $MgSO_4.7H_2O$	0.4930	MERCK's $MgSO_4.\ 7H_2O$	2.4650
,, Glucose	18.0130	,, Glucose	18.0130

CZAPEK's and RICHARD's solutions are comparatively suitable ones for them. In this experiment, CZAPEK's and RICHARD's solutions, mixed in the manner as shown on the preceding page, were used.

Each culture was set up in six sets of five ERLENMEYER flasks and placed in a thermostat at 25°C. After the incubation for a month, the mycelium was collected on previously dried and weighed filter paper, dried for three days in a steam oven at about 97°C. and weighed after cooling in the vacuum desiccator with sulphuric acid. The results are given in the following table.

TABLE XII. The mycelial yield in the liquid media.

Types	Specimen	Average dry weight of mycelia (in gm.)	
		CZAPEK's solution	RICHARD's solution
I	No. 3	0.0223	0.0167
	No. 12	0.0266	0.0163
II	No. 15	0.0243	0.0220
III	No. 27	0.0152	0.0127
	No. 29	0.0145	0.0143
	No. 30	0.0166	0.0086

In CZAPEK's solution, the mycelia of Nos. 3 and 12 of type I and No. 15 of type II submerged forming loose semicircular masses, while those of Nos. 27, 29 and 30 of type III floated on the liquid surface. In RICHARD's solution, the mycelia of Nos. 3 and 12 of type I and No. 15 of type II submerged forming compact and semicircular colonies, while those of Nos. 27, 29 and 30 of type III floated on the surface.

In general, the mycelial growth was not so good in both liquid media, and the growth in CZAPEK's solution was slightly better than that in RICHARD's. In both solutions, the mycelial weight and characters of types I and II were alike, while those of type III were quite different from the others. From these results, we may conclude that types I and II are closely related while type III is quite distinct from them.

2) *Effect of various sources of nitrogen.*

In this experiment, the standard nutrient solution used was one

consisting of KAHLBAUM's primary potassium phosphate M/100, MERCK's magnesium sulphate M/200 and glucose M/10; to this, as the nitrogen sources, were added WITTE's peptone 10 grams, MERCK's asparagine M/10, KAHLBAUM's potassium nitrate M/20 and ammonium sulphate M/20. A measured amount of 30 c.c. of sterilized solution of nitrogen compounds was added to 30 c c. of sterilized standard nutrient solution, and the mixture of required concentration was prepared. After incubation at 25°C. for a month, the mycelial yields of the fungi were determined in the same manner as in the previous experiment. The results are given in the following table.

TABLE XIII. The dry weight of mycelia in the liquid media with various nitrogen compounds.

Nitrogen sources	Average dry weight of mycelia (in gm.)					
	Type I		Type II	Type III		
	No. 3	No. 12	No. 15	No. 27	No. 29	No. 30
1. Peptone pH 5.9	0.2543	0.3279	0.2632	0.5972	0.5636	0.5971
2. Asparagine pH 3.9	0.0148	0.0251	0.0238	0.0282	0.0217	0.0228
3. Potassium nitrate pH 3.3	0.0137	0.0162	0.0117	0.0151	0.0146	0.0237
4. Ammonium sulphate pH 3.4	0.0223	0.0141	0.0615	0.0201	0.0221	0.0227

From the above table it will be seen that the mycelial growth of type III in the synthetic solution containing peptone is more vigorous than those of types I and II. It can also be seen that as a nitrogen source only peptone is of any value for mycelial growth. The growth in the solution containing amino or inorganic nitrogen is insignificant with all types compared with that in the solution with peptone. As to the characteristics of mycelial growth in each nutrient solution it was found that:

i) In the liquid medium containing peptone the mycelial growth of Nos. 3 and 12 of type I and No. 15 of type II was thick, matty and floating on the liquid surface, while that of Nos. 27, 29 and 30

of type III was also matty and floating on the surface but thicker than the former. The stale solution of types I and II changed to naples yellow to mustard yellow (RIDGWAY,[50] Plate XVI), while that of type III to a deep ochraceous-salmon to zink-orange (RIDGWAY, Plate XV).

ii) In the liquid medium containing asparagine the mycelial growth of Nos. 3 and 12 of type I and No. 15 of type II was semicircular, loose and submerged, while that of Nos. 27, 29 and 30 of type III was irregular in shape and compact and always floating on the liquid surface.

iii) In the liquid medium containing potassium nitrate the mycelial growth of all types was apparently the poorest; the appearance of growth was similar to ii.

iv) In the liquid medium containing ammonium sulphate the mycelial growth of all types was similar in appearance to ii. The mycelium of No. 15 of type II grew best in this medium, although in the medium containing potassium nitrate it was the poorest in this respect.

From these results it must be concluded that type III differs from type I or II in characteristics of the mycelial growth, while types I and II are much alike.

3) *Effect of various sources of carbohydrate.*

It is a well known fact that the carbohydrates are the best carbon sources for many fungi, and the nutritive values of different carbohydrates as carbon sources differ usually for the different fungi. Therefore cultural studies were carried out to see, if any, the different effects of carbohydrates on the fungi in question.

As the carbon source, MERCK's glucose, fructose, galactose, mannose, maltose, KAHLBAUM's lactose, saccharose, inulin and DIFCO's raffinose were added respectively in quantity of the carbon equivalent to the standard synthetic medium containing KAHLBAUM's primary potassium-phosphate M/100, MERCK's magnesium sulphate M/100 and asparagine M/10 in a litre of distilled water. The cultures were made in triplicate for each specimen. After incubation at 25°C. for a month, the mycelial yields were determined. The results of this experiment are given in the following table. The mycelial growth of type III in the medium containing maltose was more vigorous than that of types

I and II, but in the medium containing fructose, galactose, mannose or inulin, the mycelial growth of types I and II was better than that of type III, while with other carbohydrates there was found but little difference between them. The results in respect to the growth habitus of three types were similar to those of the preceding experiment, so that the same conclusions may also be drawn here.

TABLE XIV. The dry weight of mycelia in the cultural solutions with different kinds of carbohydrates.

Carbon sources		Average dry weight of mycelia (in gm.)					
		Type I		Type II	Type III		
		No. 3	No. 12	No. 15	No. 27	No. 29	No. 30
Glucose	M/10	0.0148	0.0251	0.0238	0.0282	0.0217	0.0228
Fructose	M/10	0.0118	0.0213	0.0203	0.0031	0.0034	0.0027
Galactose	M/10	0.0222	0.0224	0.0203	0.0163	0.0112	0.0182
Mannose	M/10	0.0197	0.0349	0.0151	0.0078	0.0080	0.0067
Lactose	M/20	0.0300	0.0330	0.0312	0.0322	0.0309	0.0310
Maltose	M/20	0.1070	0.1582	0.1377	0.3022	0.2906	0.2079
Saccharose	M/20	0.0103	0.0280	0.0165	0.0152	0.0179	0.0158
Raffinose	M/30	0.2206	0.1575	0.0909	0.1968	0.1989	0.2058
Inulin	M/60	0.0247	0.0238	0.0329	0.0158	0.0102	0.0135

The growth characteristics of mycelia in different media were as follows: *Glucose* — Mycelial growth of types I and II was semicircular, loose and submerged, while that of type III was irregular in shape and floating. *Fructose*, *Galactose*, *Mannose* and *Saccharose* — Mycelial growth was similar in macrospical appearance to that in the case of glucose. *Maltose* — The mycelial growth was the best. The upper part of the large mycelial mass of types I and II was elevated from the surface of the medium. The mycelium of type III floated always on the surface. *Lactose* — Mycelial growth was similar in appearance to that in the case of glucose, but those of types I and II were somewhat compact. *Raffinose* — The mycelial growths of the three types were matty and floating on the liquid surface, but in type III it was more vigorous than those of types I and II. *Inulin* —

Mycelial growth was similar in appearance to that in the case of lactose.

Judging from the growth characteristics under the different temperatures on a certain solid medium and from the mycelial growth in certain liquid media as a whole, specimens may be classified into two groups: the one comprising Nos. 3, 12 and 15, and the other Nos. 27. 29 and 30. One specimen of the former group, No. 15, however, is somewhat different from the rest of the same group as well in its mycelial growth at the various temperatures as in the characteristic appearance of the mycelium on THAXTER's glucose-potato hard agar, and in its growth characteristics in the liquid media containing ammonium sulphate, raffinose and inulin. Therefore, No. 15 may be considered as a different type, as was also found in the morphological study. Then the classification of these fungi into three types, considering type II to be a variety of type I and types I and III to be distinct species, can also be justified from these results.

D) Intracellular Enzymes.

To study the enzymic activity of these fungi the fungus meal was prepared by SCHMITZ's method as follows: — ERLENMEYER flasks of 1000 c.c. capacity were filled with sliced carrots and were sterilized in an autoclave for 20 minutes at 115–120°C. After cooling, the carrots in the ERLENMEYER flasks were inoculated with the hyphae of the different specimens grown on THAXTER's glucose-potato hard agar, and then the cultures were incubated at 25°C. Three months later, the fungus mats were separated from the carrots in tap water and then washed with distilled water. After partial drying of the fungus mats by blowing warm air over them with an electric fan, they were sufficiently dried in the vacuum desiccator over sulfuric acid. These dried fungus mats were ground into a very fine powder with a mill and kept in a refrigerator for usage in enzymic study.

For the demonstration of enzymic activity three series of experiments were carried out: in the first series, 10 c.c. of distilled water and one gram of fungus meal were put into each ERLENMEYER flask of 200 c.c. capacity. In the second series, ERLENMEYER flasks were prepared in a manner similar to that in the first and autoclaved at 110°C. In the third series, 10 c.c. of distilled water only was added to the flasks. Then, to each flask of these series 40 c.c. of the sub-

strate solution were added in such strength, that the resulting mixture contained 1% of the substrate. Adding some toluol as an anticeptic, the flasks were placed for a certain duration in an incubator at 30°C. After this, the contents of the flasks were filtered, and the filtrates were subjected to the following tests.

Reducing sugars due to enzymic action were estimated by BERTRAND's method, the potassium permanganate solution being prepared by KATO's[81] method.

1) Enzymes acting upon di-, tri- and polysaccharides.

a) *Maltase* EFFRONT[19], EULER[20] and OPPENHEIMER[50]; *Maltglucase* WENT[73]; *Glucase* GREEN[27].

To determine the activity of maltase KAHLBAUM's maltose was used as a substrate. A week later, the reducing sugar was estimated as glucose in 10 c.c. of every filtrate. Table XV shows the result of this experiment. The results of all specimens of the three types were positive and no distinct differences as to the enzymic action were found.

TABLE XV. The results of quantitative studies on maltase.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After a week's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	260.70	(158.96)	9.94	154.00	96.76
	No 12	315.70	(156.04)	52.80	154.00	108.90
II	No. 15	302.50	(163.54)	43.90	154.00	104.60
III	No. 27	314.10	(158.96)	25.60	154.00	134.50
	No. 29	305.90	(158.01)	36.98	154.00	114.92
	No. 30	310.90	(165.28)	33.15	154.00	123.75

b) *Invertase*.

KAHLBAUM's saccharose was used as a substrate. After a week of incubation, the filtrates were tested in the same manner as in the previous experiment. Table XVI shows the result of this experiment. The specimens of types I and II apparently contain this enzyme, especially abundantly in type II. Specimens of type III, with the exception of No. 29, seem also to contain this enzyme.

TABLE XVI. The results of quantitative studies on invertase.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After a week's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	20.40	(10.87)	9.94	5.91	4.55
	No. 12	112.80	(7.95)	52.80	5.91	54.09
II	No. 15	347.70	(15.45)	43.90	5.91	297.89
III	No. 27	42.00	(10.87)	25.60	5.91	10.49
	No. 29	42.78	(9.92)	36.98	5.91	(-0.11) negligible
	No. 30	43.90	(17.19)	33.15	5.91	4.84

c) *Lactase.*

KAHLBAUM's milksugar was used as a substrate. Table XVII shows the result of this experiment. In all specimens, except No. 27, the results were positive. Specimen No. 27, apparently contained no lactase, as may be seen from the table, while in all other specimens of the same type the hydrolysis of lactose by the enzyme was more vigorous than that of types I and II.

TABLE XVII. The results of quantitative studies on lactase.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After a week's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	251.60	(234.26)	9.94	229.30	12.36
	No. 12	309.20	(231.34)	52.80	229.30	27.10
II	No. 15	286.35	(238.84)	43.90	229.30	13.15
III	No. 27	255.10	(234.26)	25.60	229.30	(0.2) negligible
	No. 29	296.65	(233.31)	36.98	229.30	30.37
	No. 30	301.75	(240.58)	33.15	229.30	39.30

d) *Raffinase.*

American DIFCO's raffinose was used as a substrate. Table XVIII shows the result of the experiment. The result shows that all specimens under the experiment contained this enzyme, and the enzymic

TABLE XVIII. The results of quantitative studies on raffinase.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After a week's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	103.25	(9.92)	9.94	4.96	88.3[illegible]
	No. 12	160.40	(7.00)	52.80	4.95	102.64
II	No. 15	260.70	(14.50)	43.90	4.96	211.84
III	No. 27	119.60	(9.92)	25.60	4.96	89.04
	No. 29	122.25	(8.97)	36.98	4.96	80.31
	No. 30	120.55	(16.24)	33.15	4.96	82.44

action of type II was the most vigorous.

e) *Amylase.*

To demonstrate the presence of amylase, KAHLBAUM's soluble starch was used as a substrate. After incubation for one hour in one series and for 24 hours in the other, reducing sugar was estimated as glucose in 10 c.c. of every filtrate. Tables XIX, (a) and (b), show the results respectively. Every specimen contained this enzyme.

f) *Cellulase.*

As a substrate, filter paper, which had been soaked in tap water for a day then removed to distilled water and subsequently dried, was used. After incubation for three weeks, the filtrates were treated

TABLE XIX, (a). The results of quantitative studies on amylase.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After one hour's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	27.25	(12.98)	2.99	8.70	15.56
	No. 12	49.60	(10.49)	2.99	8.70	37.91
II	No. 15	36.20	(17.15)	11.28	8.70	16.22
III	No. 27	56.76	(12.98)	6.50	8.70	41.56
	No. 29	54.35	(12.23)	5.91	8.70	39.74
	No. 30	71.05	(21.35)	12.23	8.70	50.12

TABLE XIX, (b). The results of quantitative studies on amylase.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After 24 hour's incubation) (in mg.)				Hydrolysis Products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	126.40	(12.98)	4.01	8.70	113.69
	No. 12	247.90	(10.49)	27.25	8.70	211.95
II	No. 15	185.55	(17.15)	32.20	8.70	144.65
III	No. 27	210.00	(12.98)	11.28	8.70	190.02
	No. 29	210.00	(12.23)	24.30	8.70	177.00
	No. 30	238.70	(21.35)	24.30	8.70	205.70

as in the previous experiments. Table XX shows the result of this experiment. Each specimen of the three types contained this enzyme, though its action was variable.

TABLE XX. The results of quantitative studies on cellulase.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After 3 week's incubation) (in mg.)				Hydrolysis Products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	98.05	(4.96)	21.35	0	76.70
	No. 12	83.80	(2.04)	78.45	0	5.35
II	No. 15	69.95	(9.54)	63.75	0	6.20
III	No. 27	57.20	(4.96)	39.05	0	18.15
	No. 29	62.80	(4.01)	55.30	0	7.50
	No. 30	65.55	(11.28)	55.30	0	10.25

g) *Hadromase.*

To demonstrate the action of hadromase, fine shavings of the sapwood of the Japanese cherry tree (*Prunus Itosakura*) were used as the substrate. The shavings were soaked in tap-water for two days to remove the soluble substances, washed with distilled water and then dried. Phloroglucin and hydrochloric acid were used to stain the lignified membranes. By this treatment, the lignification of woody fibres, the wall of the vascular bundles and the medullary ray were

tested. Incubating the mixture for three weeks, the shavings were tested for CZAPEK's hadromal. The shavings taken out of each flask were submerged in HÖHNEL's chlorzinciodide[40] for 24 hours. Of the shavings, either of the series autoclaved or of the series without fungus meal, the woody fibres were sparsely stained pale yellow, and the vascular bundles and medullary rays yellowish. In the case of shavings with fungus meal, the woody fibres and wall of the vascular bundles were stained blue in each of the series, while the medullary rays were yellow. This reaction shows the decomposition of lignified membranes by hadromase with the result of exposure of cellulose from them. In this experiment, reducing sugar in the filtrate was also determined. Table XXI shows the results. The reducing sugar obtained here may be due to the action of some carbohydrases such as amylase, cellulase, pectinase, or of tannase etc., on the shavings.

TABLE XXI. The results of quantitative studies on the simultaneous production of reducing sugar with the decomposition of lignified membrane.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After 3 week's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	117.90	(5.27)	21.35	0.31	96.24
	No. 12	85.65	(2.35)	78.45	0.31	6.89
II	No. 15	72.00	(9.85)	63.75	0.31	7.94
III	No. 27	69.25	(5.27)	39.05	0.31	29.89
	No. 29	85.65	(4.32)	55.30	0.31	30.04
	No. 30	85.65	(11.59)	55.30	0.31	30.04

h) *Inulinase.*

KAHLBAUM's inulin was used as a substrate. A week later, the filtrates were treated as in the previous experiments, but the results were negative.

i) *Pectinase.*

To demonstrate the action of this enzyme, pectin from apple fruits was used as a substrate. Table XXII shows the results of this ex-

periment. All specimens of the three types contained pectinase, but the enzymic action of type II was apparently weaker than that of either type I or III.

TABLE XXII. The results of quantitative studies on pectinase.

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After a week's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	198.70	(58.36)	9.94	53.40	135.36
	No. 12	240.60	(55.44)	52.80	53.40	134.40
II	No. 15	141.70	(62.94)	43.90	53.40	44.40
III	No. 27	217.90	(58.36)	25.60	53.40	138.90
	No. 29	227.90	(57.41)	36.98	53.40	137.52
	No. 30	217.90	(64.68)	33.15	53.40	131.35

2) Glucosidases.

a) *Emulsin* (*Synaptase*)

KAHLBAUM's amygdalin and salicin were used as a substrate. Tables XXIII, (a) and (b), show the results of this experiment respectively. It was found that all specimens used for this experiment contained this enzyme.

TABLE XXIII, (a). The results of quantitative studies on emulsin. (when the substrate amygdalin was taken.)

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After a week's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	254.45	(7.50)	9.94	2.54	241.97
	No. 12	288.90	(4.58)	52.80	2.54	233.56
II	No. 15	286.35	(12.08)	43.90	2.54	239.91
III	No. 27	288.90	(7.50)	25.60	2.54	260.76
	No. 29	267.80	(6.55)	36.98	2.54	228.28
	No. 30	275.85	(13.80)	33.15	2.54	240.16

Table XXIII, (b). The results of quantitative studies on emulsin. (when the substrate salicin was taken.)

Type	Specimen	Reducing sugars as glucose in 10 c.c. of filtrate (After a week's incubation) (in mg.)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	255.30	(5.91)	9.94	0.95	244.41
	No. 12	268.75	(2.99)	52.80	0.95	215.00
II	No. 15	268.75	(10.49)	43.90	0.95	223.90
III	No. 27	264.20	(5.91)	25.60	0.95	237.65
	No. 29	273.20	(4.96)	36.98	0.95	235.27
	No. 30	264.20	(12.23)	33.15	0.95	230.10

b) *Tannase.*

Merck's tannic acid (tannin) was used as a substrate. After three weeks of incubation the filtrates was precipitated with an excess of albumin[30] and any unused albumin was then precipitated out with an excess of sodium chloride. Gallic acid in the final filtrate was estimated by Gardner[24] and Hodgson's method. Table XXIV, (a) shows the quantitative results of the experiment. Gallic acid decomposed from tannin is liable to be oxidized, so a parallel experiment was also carried out with Merck's gallic acid as a check. Table XXIV, (b)

Table XXIV, (a). The results of quantitative studies on tannase.

Type	Specimen	Gallic acid in 10 c.c. of filtrate (in mg.) (After 3 week's incubation)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	85.52	(69.41)	0	69.41	16.11
	No. 12	96.68	(69.41)	0	69.41	27.27
II	No. 15	84.28	(69.41)	0	69.41	14.87
III	No. 27	91.72	(69.41)	0	69.41	22.31
	No. 29	88.00	(69.41)	0	69.41	18.51
	No. 30	85.52	(69.41)	0	69.41	16.11

TABLE XXIV, (b). The result of quantitative studies on the oxidation of gallic acid in the presence of the fungus meal.

Type	Specimen	Gallic acid in 10 c.c. of filtrate (in mg.) (After 3 week's incubation)				Oxidation (in mg.)
		Fungus meal +substrate	Fungus meal autoclaged +substrate	Fungus meal +water	Substrate alone	
I	No. 3	150.28	(172.59)	0	172.59	22.31
	No. 12	125.49	(172.59)	0	172.59	47.10
II	No. 15	123.26	(172.59)	0	172.59	49.33
III	No. 27	125.49	(172.59)	0	172.59	47.10
	No. 29	132.31	(172.59)	0	172.59	40.28
	No. 30	146.56	(172.59)	0	172.59	26.03

shows the results of the latter experiment. It can be noticed that a considerable amount of gallic acid is lost during the incubation period which may be caused by oxidation. These experiments therefore show that every specimen of the three types contains tannase, notwithstanding the decomposition of gallic acid by some oxydases.

3) Amidases.

To demonstrate these enzymes, ammonia produced from 20 c.c. of each filtrate obtained in the following experiments was determined by SCHLÖSING's method[48].

a) *Urease.*

KAHLBAUM's urea was used as a substrate. Table XXV shows

TABLE XXV. The results of quantitative studies on urease.

Type	Specimen	Ammonia in 20 c.c. of filtrate (in mg.) (After a week's incubation in room temperature)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	59.61	(13.62)	0	13.62	45.99
	No. 12	98.77	(13.62)	0	13.62	85.15
II	No. 15	146.46	(13.62)	0	13.62	132.84
III	No. 27	30.65	(13.62)	0	13.62	17.03
	No. 29	27.25	(13.62)	0	13.62	13.63
	No. 30	34.06	(13.62)	0	13.62	20.44

the results of this experiment. All specimens of the three types contained urease. The enzymic action of type II is the most active, type I being the second and type III the third.

b) *Amidase.*

KAHLBAUM's acetamide was used as a substrate. Table XXVI shows the rusult of this experiment. In this experiment, all specimen of type III showed the negative result, while in all specimens of types I and II it were positive. As to the enzymic activity, each specimen of type I was more active than of type II.

TABLE XXVI. The results of quantitative studies on amidase.

Type	Specimen	Ammonia in 20 c.c. of filtrate (in mg.) (After a week's incubation in room semperature)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	12.26	(10.73)	0	10.73	1.53
	No. 12	11.75	(10.73)	0	10.73	1.02
II	No. 15	11.41	(10.73)	0	10.73	0.68
III	No. 27	10.73	(10.73)	0	10.73	0
	No. 29	10.73	(10.73)	0	10.73	0
	No. 30	10.73	(10.73)	0	10.73	0

c) *Asparaginase*[51].

MERCK's asparagine was used as a substrate. Table XXVII shows the results of this experiment. All specimens of types I and II contain this enzyme, while a certain specimen of type III lacks it.

4) Oxydases and other enzymes.

On these enzymes the study was made only in the qualitative way.

a) *Laccase.*

To each 0.5 grams of fungus meal from the different sources, 5 c.c. of distilled water were added, while as a control the same samples autoclaved were taken. To these, 20 c.c. of distilled water and 5 c.c. of 3 per-cent of guaiacum tincture were added. The first mixture turned to a deep blue colour after incubation at 30°C for thirty minutes, while the control remained colourless. It was demonstrated that all specimens of the three types contained this enzyme. The

TABLE XXVII. The results of quantitative studies on asparaginase.

Type	Specimen	Ammonia in 20 c.c. of filtrate (in mg.) (After a week's incubation in room temperature)				Hydrolysis products (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	6.98	(4.77)	0	4.77	2.21
	No. 12	6.98	(4.77)	0	4.77	2.21
II	No. 15	5.96	(4.77)	0	4.77	1.19
III	No. 27	4.77	(4.77)	0	4.77	0
	No. 29	6.64	(4.77)	0	4.77	1.87
	No. 30	6.30	(4.77)	0	4.77	1.53

colour in the case of types II and III was similar in its intensity and was deeper than that of type I.

b) *Tyrosinase.*

The mixture of fungus meal and water was prepared in much the same manner as in the preceding experiment. To this 20 c.c. of distilled water and 5 c.c. of saturated KAHLBAUM's tyrosin were added and then incubated at 30°C. for three days. The result of this experiment was in all specimens negative.

5) Catalase.

To demonstrate the action of catalase, 5 c.c. of distilled water were added to each 0.5 grams of fungus meal from the different sources, and a control was made in the usual way. To this 20 c.c. of distilled water and 25 c.c. of 3 per-cent commercial hydrogen peroxide were added; after incubation for one hour at 30°C. it was filtered through the porcelain-filter-crucible. Each 10 c.c. of these filtrates was titrated against the potassium permanganate solution in the presence of sulfuric acid. Table XXVIII shows the results obtained. It is evident that the three types of fungi contain this enzyme without exception.

6) Zymase.

In course of the study on pure culture of the fungi in consideration, it was noticed that the fungi produced CO_2 in the synthetic glucose media. Naturally the alcoholic fermentation was anticipated. To solve this question, the following experiment was carried out.

TABLE XXVIII. The results of quantitative studies on catalase.

Type	Specimen	Required c.c. of 0.1 N. $KMnO_4$-solution against 10 c.c. of filtrate	Per-centage of H_2O_2 decomposed by catalase
I	No. 3	73.25	24.68
	No. 12	54.00	44.47
II	No. 15	60.25	38.05
III	No. 27	71.75	26.22
	No. 29	62.25	35.99
	No. 30	67.75	29.31
Control		97.25	0

MERCK's glucose was used as a substrate. After a week of incubation, one part of each filtrate was used to determine the remaining sugar. The results are given in Table XXIX. In the other part of the filtrate the presence of alcohol was confirmed by iodform-reaction. Considering the circumstances, it may be said that these results are due to the presence of zymase in the fungi. The occurence of zymase in wood destroying fungi has not been demonstrated up to the present by any author, so far as the writer is aware.

TABLE XXIX. The results of quantitative studies on zymase.

Type	Specimen	Glucose in 10 c.c. of filtrate (in mg.) (After a week's incubation)				Glucose fermented by zymase (in mg.)
		Fungus meal +substrate	Fungus meal autoclaved +substrate	Fungus meal +water	Substrate alone	
I	No. 3	365.14	(431.61)	9.94	426.65	71.45
	No. 12	405.20	(428.69)	52.80	426.65	74.25
II	No. 15	395.70	(436.19)	43.90	426.65	74.85
III	No. 27	364.14	(431.61)	25.60	426.65	87.11
	No. 29	376.00	(430.66)	36.98	426.65	87.63
	No. 30	380.85	(437.93)	33.15	426.65	78.95

For the sake of comparison the kinds of enzymes proved to be present in various specimens are summarised as follows:

Kinds of enzyme	Type I		Type II	Type III		
	No. 3	No. 12	No. 15	No. 27	No. 29	No. 30
Maltase	+	+	+	+	+	+
Invertase	+	+	+	+	−	+
Lactase	+	+	+	−	+	+
Raffinase	+	+	+	+	+	+
Amylase	+	+	+	+	+	+
Cellulase	+	+	+	+	+	+
Hadromase	+	+	+	+	+	+
Inulinase	−	−	−	−	−	−
Pectinase	+	+	+	+	+	+
Emulsin	+	+	+	+	+	+
Tannase	+	+	+	+	+	+
Urease	+	+	+	+	+	+
Amidase	+	+	+	−	−	−
Asparaginase	+	+	+	−	+	+
Oxydase	+	+	+	+	+	+
Tyrosinase	−	−	−	−	−	−
Catalase	+	+	+	+	+	+
Zymase	+	+	+	+	+	+

From these results of the comparative study on enzymes in the fungi, though preliminary in nature, it is noticiable that it is hardly possible to classify these fungi into any definite groups or types by an attack on this side of the problem.

V. CONCLUSION.

Taking the results of the morphological and physiological studies into consideration, the fungi in consideration may be grouped into three different types. Of these, the second type is in all respects much more related to type I than to type III. The writer suggests, therefore, to treat type II as a variety of *Fomes vegetus* (FR.) COOKE (type I), and it may be named *leucostratus*.

It is also confirmed that *Fomes vegetus* (FR) COOKE is evidently a distinct or independent species from *Fomes applanatus* (FR.) GILLÉT (type III).

The diagnoses of these species are given in the following lines.

Fomes applanatus (FR.) GILLÉT: Hymen. p. 686, 1864

Syn. *Boletus fomentarius* var. *applanatus* PERS.: Syn. p. 536

Polyporus fomentarius var. *applanatus* PERS.: Myc. Eur. II, p. 80, 1825

Polyporus applanatus WALLR.: Fl. Crypt. II, p. 591, 1833

Polyporus applanatus (PERS.) FR.: Epicr. Syst. p. 465, 1838; — BERKELEY: Outl. Brit. Fung. p. 245, 1860; — QUÉLET: Champ. Jura et Vosges p. 279, 1869; — COOKE: Handb. Brit. Fung. p. 274, 1871; — FRIES: Hym. Eur. p. 557, 1874; — STEVENSON: Brit. Fungi II, p. 204, 1886

Polyporus applanatus (PERS.) WINTER: Pilze p. 425, 1884

Placodes applanatus (PERS.) QUÉL.: Ench. Fung. p. 171, 1886

Fomes applanatus (PERS.) WALLR.: SACCARDO's Syll. Fung. VI, p. 591, 1888; — pp. NEUMAN's Wisc. Geol. Nat. Hist. Sur. Bull. XXXIII, p. 83, 1914; — pp. YASUDA's Herb.

Phaeoporus applanatus (PERS.) SCHRÖTER: Pilze, p. 490, 1888

Ganoderma applanatus (PERS.) PAT. Bull. Soc. Myc. V, p. 67, 1889; — BOURDOT et GARZIN: Hym. Fran. p. 611, 1928; — REA: Brit. Basid. p. 597, 1922

Ganoderma leucophoeum (MONTG.) PAT.: Bull. Soc. Myc. V, p. 73, 1889

Fomes applanatus (WALLR.) MASSEE: Brit. Fung. Fl. I, p. 224, 1892

pp. *Ganoderma lipsiensis* (BATSCH.) ATKINS.: Ann. Myc. VI, p. 189, 1901

Fomes applanatus KARST.: SMITH's Syn. Brit. Basid. p. 348, 1908

pp. *Fomes applanatus* BULL.: Research. Fungi I, p. 37, 1909

Fomes applanatus (PERS.) MIGULA: Crypt. Fl. Pilze, p. 193; 1912

Ganoderma applanatus (FR.) BRES.: Hedwigia p. 313, 1912

pp. *Fomes applanatus* LLOYD: Syn. Gen. Fomes, p. 264, 1915

pp. *Fomes leucophaeus* LLOYD: Ibid.

pp. *Fomes leucophaeus* MONT.: YASUDA's Herb.

Pileus horizontal, flat, semicircular or kidney shaped, sessile or sometimes with a short lateral stalk, concentrically zoned, often tuberculate, at first covered with the ferruginous conidial spores, then

grayish white with a corneous crust; margin obtuse; context tissue interposed between the crust and tube layer, at first punky, context tissue and tube layers concolorous, commonly ferruginous with various shadings owing to the different host; tubes indistinctly stratified, not interposed by context layer; under surface at first whitish or yellowish, later pink in colour, quickly changing to dark-brown when bruised; mature spores ferruginous, warty, obovate, becoming truncate at the base, measuring $9.09 \pm 0.03 \times 5.88 \pm 0.025\ \mu$; cystidia none.

Hab. On living or dead trunks of *Abies sachalinensis, Acer pictum, Carpinus Tschonoskii, Celtis sinensis* var. *japonica, Pasaniopsis Sieboldi, Diospyros Kaki, Prunus Mume, Prunus Itosakura, Quercus stenophylla, Ligustrum ovalifolium,* etc.

Distrib. Very common in the main-land of Japan and also found at Tomakomai, Hokkaidô.

Fomes vegetus (FR.) COOKE: Grev. XIV, p. 18, 1885

Syn. *Polyporus vegetus* FR.: Epicr. Syst. p. 464, 1838; — BERKELEY: Outl. Brit. Fung. p. 245, 1860; — COOKE: Handb. Brit. Fung. p. 274, 1871; — FRIES: Hym. Eur. p. 556, 1874

Fomes vegetus (FR.) SACC.: Syll. Fung. VI, p. 179, 1888

Phaeoporus vegetus (FR.) SCHRÖTER: Pilze p. 490, 1888

Ganoderma australe (FR.) PAT.: Bull. Soc. V, p. 71, 1889

Fomes vegetus (FR.) MASSE: Brit. Fung. Fl. Vol. 1, p. 223, 1892

Elfvingia megaloma (LÉV.) MURRILL: Bull. Torr. Bot. Club Vol. XXX, p. 300, 1903; — North. Amer. Fl. Vol. 9, p. 114, 1908; — North. Polyp. p. 53, 1914; — South. Polyp. p. 54, 1915

pp. *Ganoderma lipsiensis* (BATSCH.) ATKINS.: Ann. Myc. Vol. VI, p. 189, 1908

Fomes vegetus KARST.: SMITH's Syn. Brit. Basid. No. 1576, 1908

pp. *Fomes vegetus* BULLER: Researches Fungi I, p. 32, 1909

Fomes vegetus (FR.) MIGULA: Krypt. Fl. Pilze, p. 193, 1912

Polyporus applanatus (PERS.) GRAMBERG: Pilze uns. Heimat 1913

pp. *Fomes applanatus* (PERS.) WALLR.: NEUMAN's Wisc. Geol.

Nat. Hist. Sur. Bull. XXXIII, p. 83, 1914
pp. *Fomes applanatus* LLOYD: Syn. Gen. Fomes p. 264, 1915
pp. *Fomes leucophaeus* LLOYD: Ibid.
Ganoderma vegetum (FR.) PAT.: SACCARDO's Ital. Crypt. XV, p. 1012, 1916
pp. *Fomes applanatus* (PERS.) WALLR.: YASUDA's Herb.
pp. *Fomes leucophaeus* MONT. Ibid.

In the outer features, this species is quite similar to *Fomes applanatus*, but differs from it in the context tissue layer interposed between the tube layers. The mature spores are ferruginous, warty, obovate, becoming truncate at the base, measuring $7.80 \pm 0.024 \times 5.34 \pm 0.019\ \mu$.

Hab. On living or dead trunks of *Acer pictum* *Alnus alnobetula* var. *fructicosa*, *Betula japonica*, *Fagus japonica*, *Micromeles alnifolia*, *Quercus grosseserrata*, *Salix Urbaniana*, *Tilia japonica* etc.

Distrib. Very common in Hokkaidô.

Fomes vegetus (FR.) COOKE var. **leucostratus** n. n.
Syn. *Ganoderma applanatus* (PERS.) PAT. var. *vegetum* (FR.) ROMELL: REA's Brit. Basid. p. 597, 1922

It is very closely related to *Fomes vegetus*, but differs from that type in the white mycelial layer interposed between the tube layers. The mature spores are ferruginous, warty, obovate, becoming truncate at the base, measuring $8.24 \pm 0.03 \times 5.17 \pm 0.02\ \mu$.

Hab. On dead trunks of *Quercus grosseserrata*.

Distrib. Hokkaidô.

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EXPLANATION OF PLATES.

PLATE IV.

1. The upper-surface of the sporophore of *Fomes vegetus* (FR.) COOKE (type I, No. 3)
2. The upper-surface of the sporophore of *Fomes vegetus* (FR.) COOKE var. *leucostratus* n. n. (type II, No. 15).
3. The upper-surface of the sporophore of *Fomes applanatus* (FR.) GILLÉT (type III, No. 29).
4. The strata of the tube layers in a longitudinal section of *Fomes vegetus*. Natural size.
5. The strata of the tube layers in a longitudinal section of *F. vegetus* (FR.) COOKE var. *leucostratus* n. n.
6. The strata of the tube layers in a section of *F. applanatus* (FR.) GILLÉT.
7. The pyriform spores, having fallen naturally, of *F. applanatus* (FR.) GILLÉT. ×950.
8. The verruciform epispore of *F. applanatus* (FR.) GILLÉT. ×1100.
9. Teraspores of *F. applanatus* (FR.) GILLÉT. ×1400.
10. Much magnified spores of those in Fig. 8. ×1750.

PLATE V.

Figs. 1–6. Mycelial growths on THAXTER's glucose-potato hard agar plates, after a week.

1. Type I, No. 3.
2. Type I, No. 12.
3. Tppe II, No. 15.
4. Type III, No. 27.
5. Type III, No. 29.
6. Type III, No. 30.

Figs. 7–12. Mycelial growths on Carrot agar plates, after a week.

7. Type I, No. 3.
8. Type I, No. 12.
9. Type II, No. 15.
10. Type III, No. 27.
11. Type III, No. 29.
12. Type III, No. 30.

Figs. 13–15. Mycelial growths on Onion agar plates, after a week.

13. Type I, No. 3.
14. Type I, No. 12.
15. Type II, No. 15.

PLATE VI.

Figs. 1–3. Mycelial growths on Onion agar plates, after a week.

1. Type III, No. 27.

2. Type III, No. 29.
3. Type III, No. 30.

Figs. 4–9. Mycelial growths on Appricot agar plates, after a week.

4. Type I, No. 3.
5. Type I, No. 12.
6. Type II, No. 15.
7. Type III, No. 27.
8. Type III, No. 29.
9. Type III, No. 30.

Figs. 10–15. Mixed cultures between the inocula from the same source of the samples, on THAXTER's glucose-potato hard agar plates, after a week.

10. Type I, No. 3.
11. Type I, No. 12.
12. Type II, No. 15.
13. Type III, No. 27.
14. Type III, No. 29.
15. Type III, No. 30.

PLATE VII.

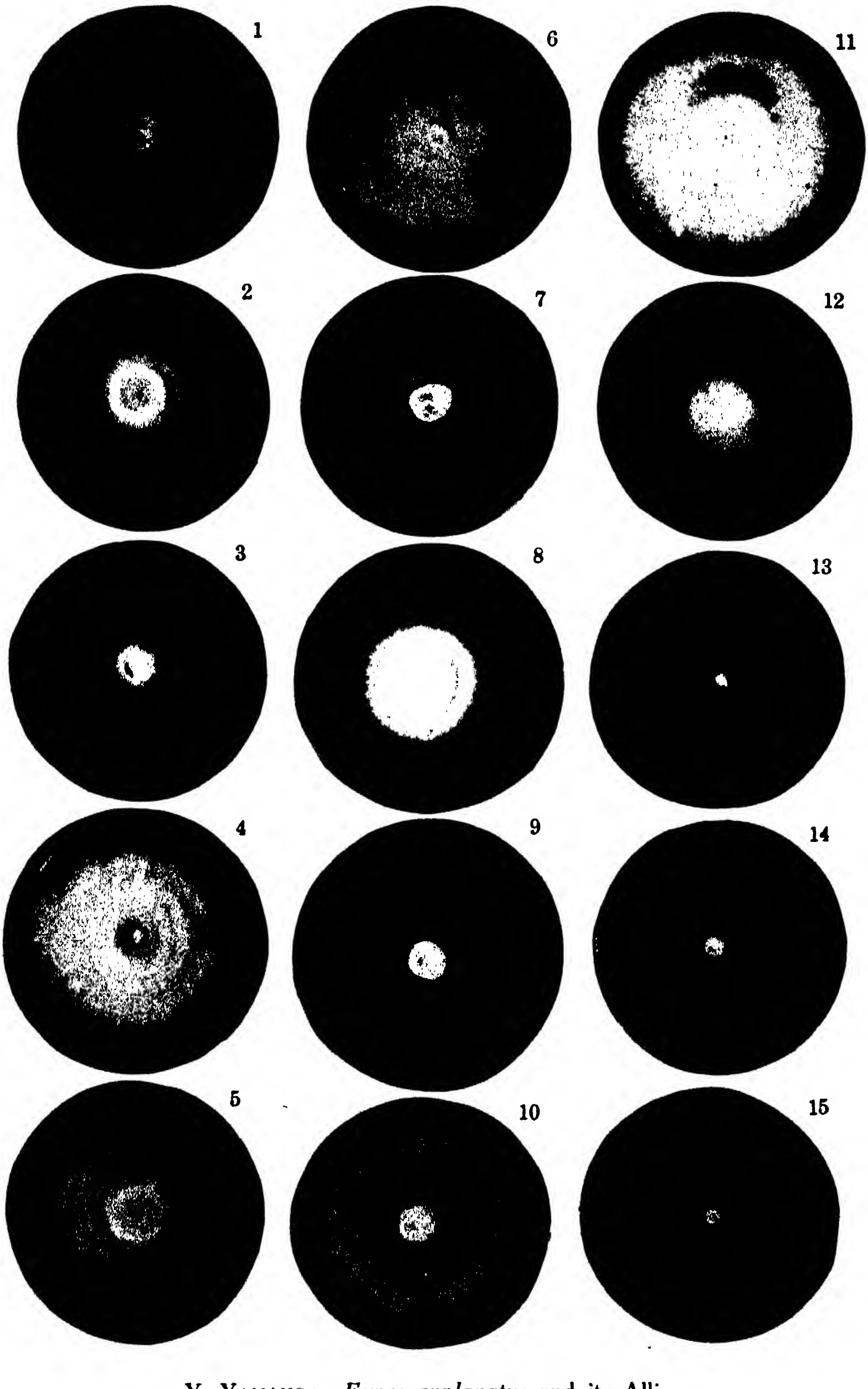
Mixed cultures by the inocula from the different sources on THAXTER's glucose-potato hard agar plates after a week.

a. No. 3; b. No. 12; c. No. 15; d. No. 27; e. No. 29; f. No. 30.

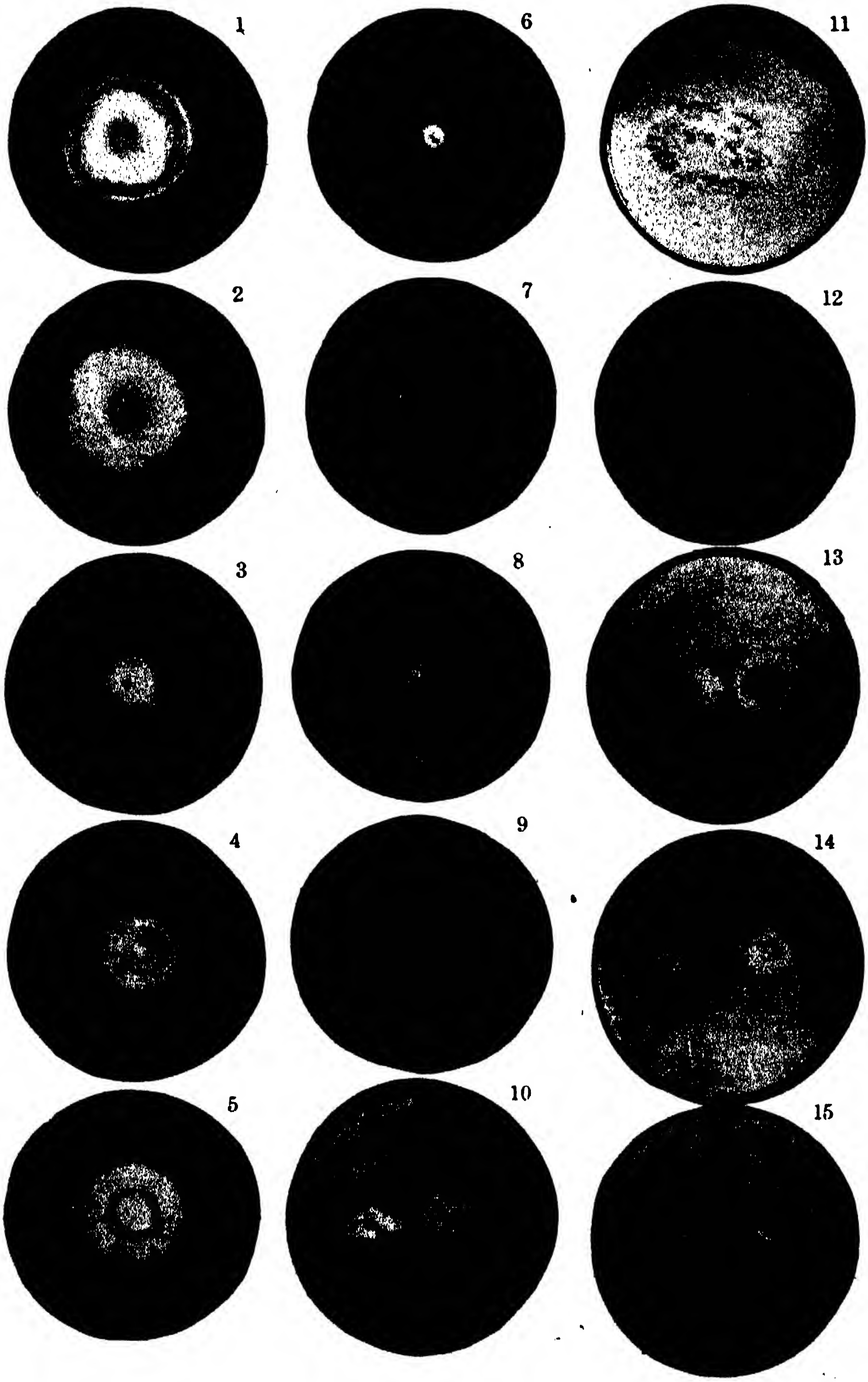
Figs. 1–3. Mixed cultures between the different samples in types I and II.

Figs. 4–6. Mixed cultures between the different samples in type III.

Figs. 7–15. Mixed cultures between the different samples in types I, II and III.



Y. YAMANO: *Fomes applanatus* and its Allies.



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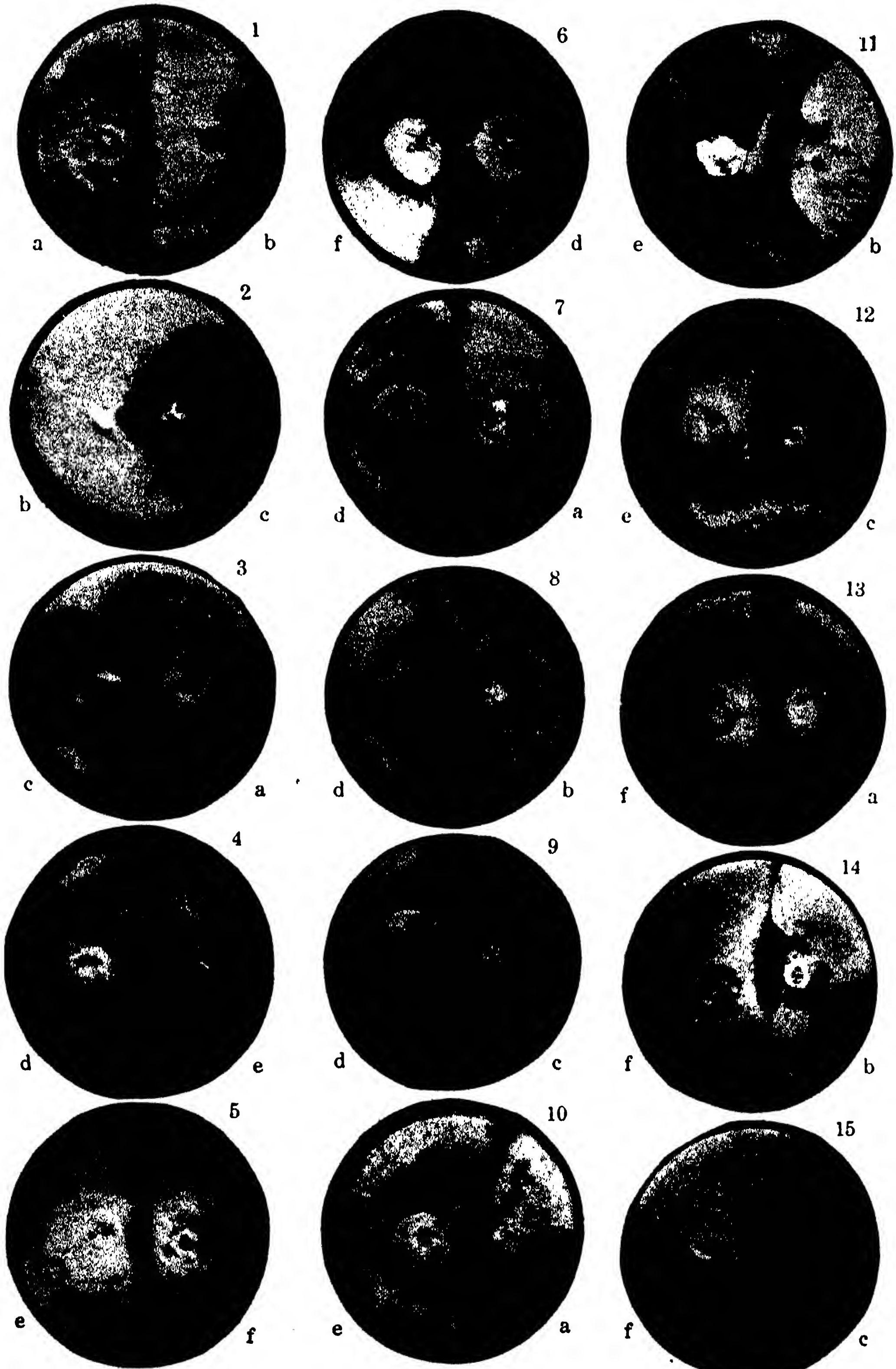

Y. YAMANO: *Fomes applanatus* and its Allies.

On the Gaseous Exchange in *Synedra* sp.

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(With 11 text-figures).

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I. INTRODUCTION.

In contrast to the immense abundance of researches on the gaseous exchange in lower and higher green plants, knowledge of this function in diatoms suffers even now from its uncertainty because of various difficulties. Diatoms do not increase so easily and contain the pigment (diatomin) of yellowish-brown color and, moreover, they secrete a gelatinous substance which attaches to the periphery and hardly permits a pure culture to be successful. These facts present drawbacks to the study of the function of the gaseous exchange of these organisms. ENGELMANN (1886) first proved by his " Bakterienmethode " that diatoms put out oxygen in the light. A few years later, from the oxydation of haematoxylin, PALMER (1897) also demonstrated the function of diatoms to assimilate carbon dioxide.

In connection with pure culture, the cell division under monochromatic light has been researched by MEINHOLD (1911); but as to the gaseous exchange he concerns himself only with the grade of CO_2-assimilation in each monochromatic light, determined by the grade of increase in number. Recently MARSHALL and ORR (1928) discussed the CO_2-assimilation of diatoms at various depths in the sea by using liquid culture; in this research the light intensity was measured only on the surface of the sea. As is conceivable from the situation of their experiment, it was hardly possible for them to control the other factors.

As such is the case for the present, our knowledge on the function under consideration of diatoms can only be increased by quantitative study under rigorous control of the various environmental factors.

The aim of the present study is to throw some light on this field of the subject.

I wish to express my hearty thanks to Professor Doctor Y. YAMAGUTI for his valuable advice and suggestions throughout the progress of this work.

II. MATERIAL.

Under the microscope *Synedra* was picked out with a micromanipulator from the sample of plankton which was collected from Matsushima Bay, and held in a PETRI dish filled with sea water containing nutrient salts; after being caught it was transferred to the previously prepared culture medium in an ERLENMEYER flask. This procedure of isolation was repeated several times. Rapid increase can not be expected on agar-agar medium with inorganic nutrient salts. So the organism was cultured in a liquid medium after ALLEN and NELSON's method (1910). In this experiment the culture medium was sterilized by water vapour at 100°C. after filtering off the precipitates, caused by the addition of nutrient salts and by heating it, from the culture medium.

ERLENMEYER flasks, previously sterilized, containing isolated *Synedra* were placed near the north window and protected from the exposure to direct sun light. An electric light lamp illuminated them in the night time. This organism shows a brownish color in the culture. If it becomes a dirty opaque pale brown, it usually loses its activity in part. To prevent it from entering into this state the nutrient media were renewed every 10 days.

In respect to pure culture, half a year or more is needed to succeed in getting pure diatoms, even when they increase very rapidly (RICHTER, 1903, MEINHOLD, 1911). But in *Synedra* and other cases where they grow gently it is conceivably amost impossible to succeed in getting a pure culture of it to carry on the study as here undertaken. The efforts in this direction proved themselves to be always negative, because of its slow multiplication and its habit of forming a gelatinous substance, though not much, and of the fact that this organism on the agar-agar medium with inorganic nutrient salts, not to mention organic salts, was easily overcome by bacteria. So the culture used

was not entirely free from microorganisms, but the greatest care was taken to remove or prevent the increase of microorganisms.

In the experiments, the culture was always used in the same condition. As the main points for this criterion, the duration of the culture and the color of the diatoms, of which the latter changes remarkable in tone according to the activity of the organism, were chosen. Between the samples of the same duration of culture was hardly found any difference in the amount of gaseous exchange.

III. METHOD.

The gaseous exchange in this organism is measured by the manometric method described by WARBURG (1919, 1923) (also see SHIBATA, 1929).

Synedra in culture media are first separated by a centrifugal machine under a small number of turns and then 0.1 ccm of this organism is obtained by a larger number of turns (1500 turns per minute) for five minutes. The collected organism is transferred to new sterilized sea water and, after repeating the same procedure several times, it is taken into sterilized sea water containig bicarbonate-carbonate mixture to be ready for the following experiments.

As CO_2-source, the mixture of 95 parts of the solution of natrium bicarbonate and 5 parts of natrium carbonate is used (ANGELSTEIN, 1911, WARBURG, 1919). This mixture always produces CO_2 in a constant pressure. In various concentrations it is added to the sterilized sea water. 5 ccm of sea water prepared in this way are transferred to the trough together with 0.1 ccm of the organism.

Metal filament electric light lamps are used as the light source. In the majority of cases the lamp is placed outside the water thermostat, and by varying its distance from the though the light intensities are controlled. All the experiments are carried out in the water thermostat, of which the temperature can be maintained up to 1/10 degree constant. The light (Fig. 1, L) passes through the thick water layer in the water thermostat (WT), and is reflected by the mirror (M) in water to illuminate the trough (T) rectangularly from its base. In a few cases where the lamp is placed in the water thermostat the trough is illuminated directly by the lamp. Between two slits (ss and

s′s′) a ground glass plate (G), to extinguish the immage of the lamp, are inserted into the path of the light. The light intensity is indicated

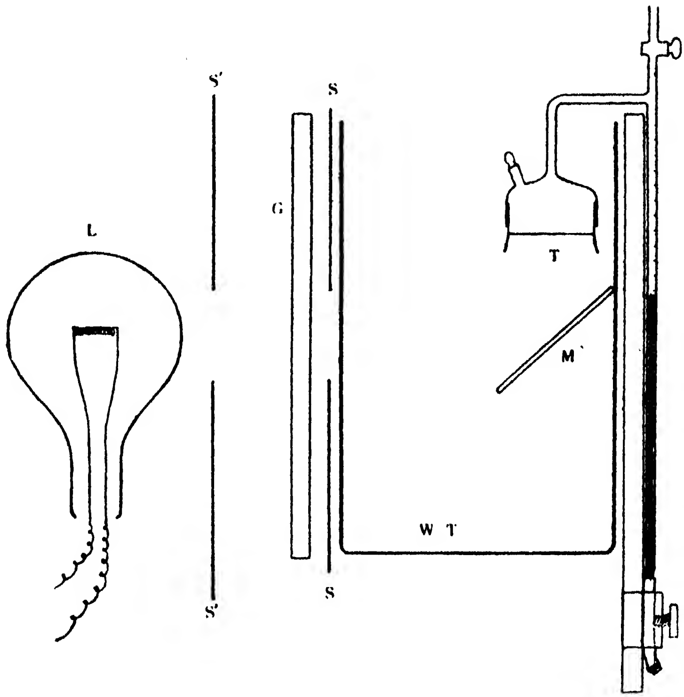

Fig. 1.

by the deflection reading in mm of the mirror galvanometer at the distance of one metre, which is connected to the thermopile (MOLL system) held at the same position as that of the through.

Measurements are made in two ways:

A. The rate of assimilation and respiration is alternately measured under the alternation of light and dark in a short period (WARBURG, 1922). This way of measurement is necessary for the sake of maintainance of a constant temperature, especially in the case of strong light intensity at a low temperature. The acceleration of respiration is not noticed as in the case of *Chlorella* (WARBURG, 1922).

B. The rate of assimilation and respiration is measured separately for some due duration. Cases are taken to use the same trough throughout both measurements.

IV. INFLUENCE OF CO_2-CONCENTRATION.

In sea water many salts are dissolved and they are in an equilibrial state. If, however, bicarbonate and carbonate are dissolved in sea water, some changes in this equilibrium among those salts will occur and the relation between them will generally be changed. So the state of bicarbonate-carbonate mixture in sea water may be different from that in fresh water. On this account no accurate statement can be made on the state of bicarbonate-carbonate mixture in sea water; only it may be anticipated to some extent that the more concentrated the mixture in sea water, the more available CO_2 for CO_2-assimilation will be put out.

As to the effect of bicarbonate-carbonate mixture on CO_2-assimilation in *Synedra*, it is found to be as shown in Table 1. From this

TABLE 1.

Relative light intensity 45.5. Temperature 16°C.

Concentration of $NaHCO_3$-Na_2CO_3-mixture in Mol	Duration of experiment in minutes	CO_2-assimilation in cmm O_2	CO_2-assimilation per hour in cmm O_2
1/400	10	2.6	15.6
1/200	10	3.5	21.0
1/100	10	4.6	27.6
1/80	10	4.8	28.8
1/40	10	5.4	32.4
1/20	10	6.2	37.2

table it may be seen that in concentrated bicarbonate-carbonate mixtures CO_2-assimilation is more extensive than that in the diluted ones (WARBURG, 1919, HARDER, 1921).

It is worthy of mention here, that when many hours pass after the addition of bicarbonate-carbonate mixture to sea water, the deposition of carbonate becomes so evident that it may be seen on the wall of a glass dish with the naked eyes. Therefore, care is taken in preparation to dissolve the bicarbonate carbonate mixture into the sea water just before the experiments begin.

V. INFLUENCE OF LIGHT INTENSITY.

As stated above the light intensity is controlled by the change of

distance between the light source and the trough. It is measured in each experiment. The results of studies on the effect of various light intensities on the gaseous exchange of *Synedra* are given in Table 2 (also see Fig. 2).

TABLE 2.

1/100 Mol $NaCO_3$-Na_2CO_3-mixture as CO_2-source.
Temperature 16°C.

Light source	Distance between lamp and trough		Deflection reading of galvanometer in mm	Relative light intensity	Duration of experiment in minutes	CO_2-assimilation in cmm O_2	CO_2-assimilation per hour in cmm O_2
	air	water					
watt	cm	cm					
100	41.6	49.0	8.2	1	70	0.6	0.5
100	20.6	49.0	15.6	1.9	70	6.2	5.3
100	10.0	49.0	25.8	3.1	70	11.3	9.7
100	4.0	49.0	34.9	4.3	70	16.8	14.4
200	1.5	59.0	44.6	5.4	70	20.2	17.3
200	1.5	49.0	55.5	6.8	20	6.8	20.4
12.5	—	11.7	72.5	8.9	20	7.9	23.7
12.5	—	9.0	102.9	14.2	10	4.5	27.0
12.5	—	6.7	200.4	24.2	10	4.9	29.4
12.5	—	5.0	373.0	45.5	10	5.3	32.1
20	—	5.0	—	—	10	7.8	46.8

From these results it is clear that in small light intensity the light acts on CO_2-assimilation as a limiting factor in the above condition, so that the CO_2-assimilation is found to increase approximately in proportion to the light intensity; the curve runs lineal (Fig. 2). This result agrees with that of former investigators (PANTANELLI, 1904, BLACKMAN, 1905, BLACKMAN and MATHAEI, 1905, BLACKMAN and SMITH, 1911, WARBURG, 1919, HARDER, 1921). With the increase of light intensity, however, the increase in the rate of CO_2-assimilation corresponding to the increase of each unit of light intensity becomes smaller. In the greater light intensities the rate of increase in CO_2-assimilation diminisches so far that the curve runs rather parallel to the abscissa (WARBURG, 1919, HARDER, 1921).

The results obtained by method B are shown in Table 3 and Figs. 3 a — 3 f. In smaller light intensities they show hardly any differences in the amount of assimilation from the results found by method A, while in greater light intensities the results obtained by method B are a little larger than those resulting from method A.

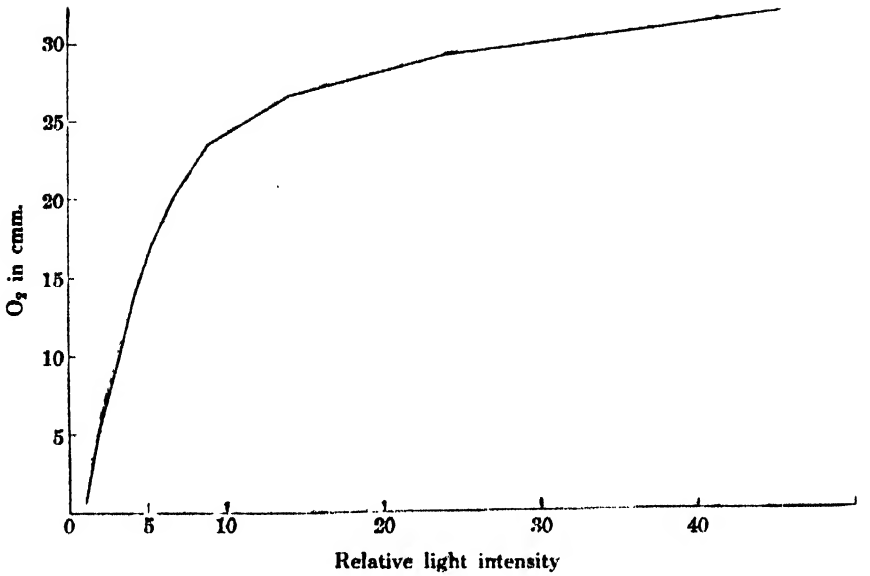

Fig. 2.

The cause of this deviation may possibly lie in the rising of the temperature in the trough during the experiments, because after a long illumination the manometer is found for a while not to indicate the changes in pressure caused by respiration, when the light is removed. So the correction for this case must be introduced into the calculation.

VI. INFLUENCE OF TEMPERATURE.

Next, to know how the temperature may be effective on the rate of CO_2-assimilation and respiration, the following experiments were made. The range of light intensities experimented was 6.8, 45.5 (s. Table 2, fifth column) and 20 watt lamp at a distance of 5 cm from the trough in water.

As may be taken from Table 4, in the case of the light intensity 6.8, the rate of the apparent CO_2-assimilation decreases in its value with the ascending of the temperature over 16°C., but taking into consideration the CO_2-production by respiration at the same time, no change results in its amount of assimilation at higher temperatures

TABLE 3.

Temperature 16°C. Volume in cmm O_2.

Relative light intensity	1.0			1.9			3.1			4.3			5.4			6.8 (a)*			6.8 (b)		
Time in minute	Respiration	Apparent assim.	Assimilation	Respiration	Apparent assim.	Assimilation	Respiration	Apparent assim.	Assimilation	Respiration	Apparent assim.	Assimilation	Respiration	Apparent assim.	Assimilation	Respiration	Apparent assim.	Assimilation	Respiration	Apparent assim.	Assimilation
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0.6	-0.7	-0.1	0.6	-0.2	0.4	0.5	0	0.5	0.4	0.6	1.0	0.6	0.4	1.0	0.5	1.0	1.5	1.4	1.0	2.4
15	2.1	-2.0	0.1	2.4	-1.0	1.4	1.8	0.1	1.9	2.3	1.6	3.9	2.2	2.3	4.5	2.0	4.3	6.3	3.3	3.1	6.4
30	4.6	-4.3	0.3	4.6	-2.1	2.5	4.9	0.2	5.1	4.9	2.6	7.5	4.6	4.4	9.0	5.2	8.2	13.4	5.2	6.3	11.5
50	7.1	-6.6	0.5	7.9	-3.4	4.5	7.9	0.3	8.2	8.2	4.7	12.9	7.3	7.5	14.8	8.5	13.2	21.7	9.0	10.8	19.8
70	10.0	-9.3	0.7	11.1	-5.0	6.1	11.0	0.4	11.4	11.5	6.5	18.0	10.2	10.6	20.8	12.2	19.2	31.4	10.9	15.4	26.3
90	13.3	-11.9	1.4	14.0	-7.2	6.8	14.4	0.5	14.9	13.8	8.1	21.9	13.3	13.9	27.2	15.3	24.5	39.8	15.8	19.0	34.8
110	16.7	-14.7	2.0	17.7	-8.9	8.8	17.2	0.6	17.8	16.9	9.9	26.8	16.2	16.6	32.8	19.3	28.9	48.2	19.0	23.6	42.6
130	19.5	-17.0	2.5	21.5	-10.0	11.5	21.4	0.6	22.0	20.7	12.0	32.7	19.2	18.8	38.0	23.0	33.2	56.2	21.9	28.1	50.0

* Volume increases by illumination are not corrected.

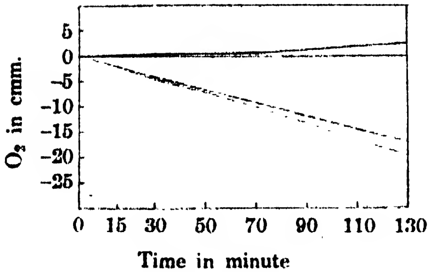

Fig. 3 a. Relative light intensity 1.

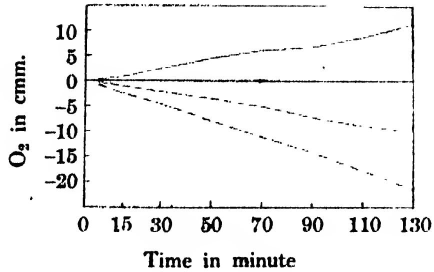

Fig. 3 b. Relative light intensity 1.9.

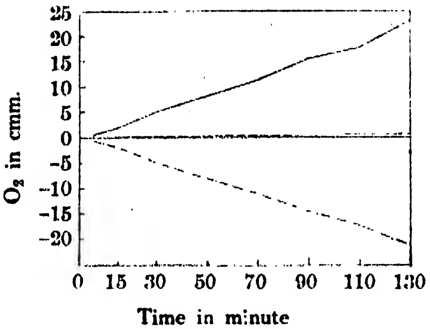

Fig. 3 c. Relative light intensity 3.1

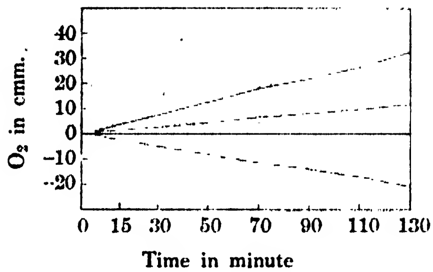

Fig. 3 d. Relative light intensity 4.3.

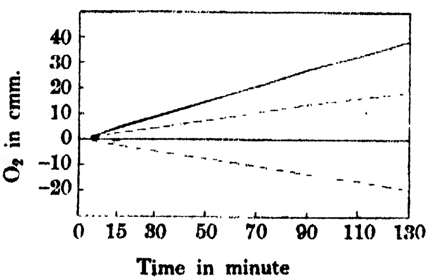

Fig. 3 e. Relative light intensity 5.4.

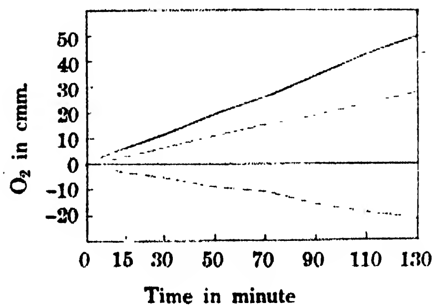

Fig. 3 f. Relative light intensity 6.8 (b).

——— Assimilation.
— — — Apparent assimilation.
—·—·— Respiration.

TABLE 4.
1/100 Mol $NaHCO_3$-Na_2CO_3-mixture as CO_2-source.

Light intensity	6.8			45.5			20 watt lamp		
Temperature	Respiration per hour in cmm O_2	Apparent assimilation per hour in cmm O_2	Assimilation per hour in cmm O_2	Respiration per hour in cmm O_2	Apparent assimilation per hour in cmm O_2	Assimilation per hour in cmm O_2	Respiration per hour in cmm O_2	Apparent assimilation per hour in cmm O_2	Assimilation per hour in cmm O_2
6°C.	4.8	5.4	10.2	5.1	7.5	12.6	5.4	10.4	15.8
11°	6.9	10.7	17.6	7.8	17.7	25.5	7.5	26.7	34.2
16°	8.9	11.4	20.3	9.3	22.8	32.1	8.9	38.0	46.9
21°	15.2	4.9	20.1	15.9	18.3	34.2	17.0	33.4	50.4
26°	30.2	-9.7	20.5	28.8	5.4	34.2	30.3	22.2	52.5

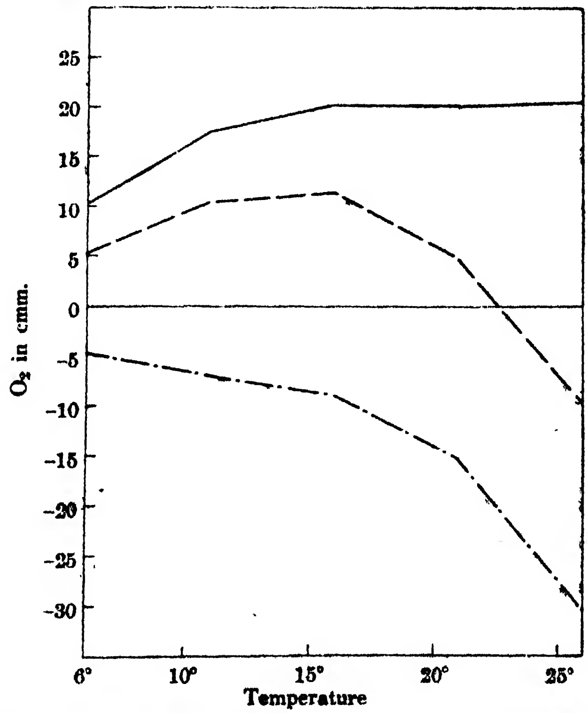

Fig. 4. Relative light intensity 6.8. ——— Assimilation, – – – Apparent assimilation, —·—·— Respiration.

than 16°C. (Table 4 and Fig. 4). In this case the light acts upon the assimilation as a limiting factor, so that in spite of the ascending of the temperature no effect upon the CO_2-assimilation can be produced (BLACKMAN, 1905). Between 6°C. and 16°C. the assimilation increases gradually with the rise of temperature.

With the light intensity 45.5, a similar effect is found (Fig. 5),

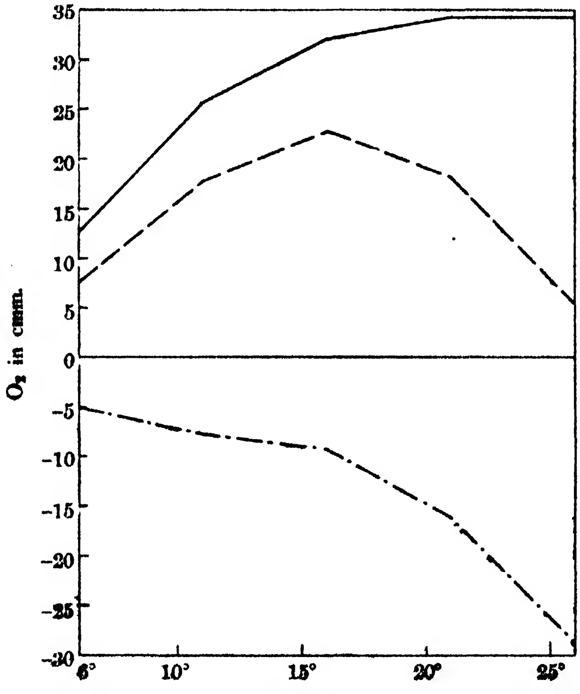

Fig. 5. Relative light intensity 45.5. ———— Assimilation, — — — Apparent assimilation, —·—·— Respiration.

but in this case the assimilation increases with the accending of the temperature up to 21°C.. In the case of a 20 watt lamp (Fig. 6), the assimilation further increases with the ascending of the temperature up to 26°C., though the rate of increase in assimilation diminishes gradually with the ascending of the temperature. It is remarkable that the apparent assimilation in this experiment has only one optimum point while in other plants are found many optimum points (LUNDEGÅRDH, 1924).

Considering these experiments, it can be suggested that the assimilation (and also the apparent assimilation) in *Synedra* will increase

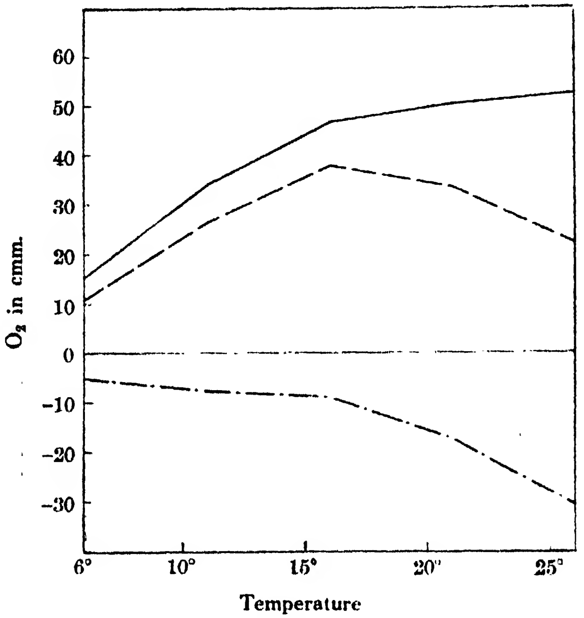

Fig. 6. 20 watt lamp. ——— Assimilation, — — · · Apparent assimilation, —·—·— Respiration.

to some extent in linear function with light intensity and ascending of the temperature. M. YABUSOE (1924) has also observed that the assimilation increases lineally with the ascending of the temperature in the range of 10°C. to 30°C. in *Chlorella*. This seems to be a case in which the light and CO_2-tension are sufficient enough, but not so strong as to injure the cells. With reason, he has taken into consideration the decrease of temperature quotient with the ascending of the temperature, so that the curve of assimilation in this case can not be lineal. A similar tendency is also observed in this experiment.

The temperature coefficient is considered. From the results in the case of experiment with a 20 watt lamp, we obtain:

between	6°C. and 11°C.	$Q_{10}=4.6$
	11°C. and 16°C.	$Q_{10}=1.9$
	6°C. and 16°C.	$Q_{10}=2.9$

As the value of Q_{10} between 11°C. and 16°C. is smaller than that between 6°C. and 11°C., the light comes to limit the assimilation at least at a temperature higher than 11°C.. The high value of Q_{10} as here found is also reported in the researches of other plants (WARBURG, 1919, LUNDEGÅRDH, 1924).

When the organism is illuminated by a light of 3.1, the compensation point is found at 16°C.. With the greater light intensities, it shifts from this point to the higher ones to maintain the assimilation and respiration equal (PLEATZER, 1917). So, for example, the gaseous exchange arrived at the compensation point at a temperature higher than 21°C., when illuminated by a stronger light of 6.8.

VII. SUMMARY.

Experiments on the gaseous exchange in *Synedra* in liquid culture under the careful control of various factors have given the following results:

1) In the presence of more concentrated CO_2-source, CO_2-assimilation is stronger than that in diluted ones.

2) The light curve of CO_2-assimilation is almost linear for the range of smaller light intensities. With the increase of light intensity the rate of CO_2-assimilation becomes smaller.

3) CO_2-assimilation increases with the ascending of the temperature up to the point at which the light comes to limit the assimilation.

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Notes on the Effect of Centrifugal Force on the Frog's Egg.

By

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(With 18 Text-figures).

Since HERTWIG's observation ('99) on the centrifuged frog's egg, many authors have studied the same problem in Amphibia. They are; MORGAN ('02, '06), WETZEL ('04), GURWITSCH ('04, '09), KNOPACKA ('08), MACCLENDON ('09, '10), JENKINSON ('14), BANTA et GORTNER ('15), SCHAXEL ('22), OEDQUEST ('22) and BAGINI ('23, '25). In the spring of 1929, I also repeated this experiment on the egg of the Japanese frog, *Rana japonica* GÜNTHER. And I took note of an interesting tendency of the deformation of the embryo, which has passed the gastrulation stage without developing into a ring embryo or a spina bifida. I have set out below the observations.

OBSERVATION.

A batch of fertilized and unsegmented eggs of *Rana japonica* were divided into two groups and were centrifuged on an electrically driven machine of a radius of 14 cm. The first group was operated about ten minutes at a speed of 3000 revolutions per minute which is equal to 1400 times gravity, and the second group five minutes at a speed of 2000 revolutions per minutes which is equal to 600 times gravity. After removal from the machine, complete stratification of the visible materials in the egg cell was observed in both groups, and the animal pole of the egg became light gray and uneven. After a few days many permanent blastula, ring embryos and *spina bifida* appeared in both groups and, soon after, most of the operated embryo disintegrated, especially in the first group. Six days later I got about sixty specimens, which have fortunately finished the gastrulation and showed larval forms. They have a closed blastopore but about seventy per

cent of the specimens showed deformations of various grades. The deformations are classified into four types.

Type I. In this type the distortions are limited to the anterior end of the body, that is, the olfactory pits approach the median line. One example of this type is shown in Figures 3, 4 and 14. Body measures 12 mm. in length and 2 mm. in width. Olfactory pits approach the median line. On this account the anterior end of the boʊy is peaked (Fig. 4). Mouth, sucker and other external features are normal. In section it is observed that the olfactory pits of both sides do not fuse into each other, but they nearly touch at the bottom (Fig. 14). Eye cups, eye lenses, auditory vesicles and other cranial ganglia are normal. Telencephalon is a little smaller than a normal one. Pronephros and heart are normal.

Type II. In this type the deformation is more advanced than in in the first type. The olfactory plates fuse into the median line from both sides, and the eyes have developed incompletely. For example, Figs. 5, 6 and 15. This specimen measures 9.5 mm. in length and 2 mm. in width. The head is smaller than the normal, and peaked (Fig. 6). One olfactory plate has developed at the anterior end of the body, as if it is an eye in a cyclopian monster (Fig. 5). Buccal cavity not observed. Sucker incompletely developed. Differentiation of the cornea is not seen and, therefore, the position of eye is not distinct from outside. In section the sign of fusion of the olfactory plates is indicated (Fig. 15). Eye cups are present at both sides of the brain but they lie in a very deep position from the overlieing epidermis and are smaller than normal. The retina shows normal structure but the differentiation of the lens is not observed (Fig. 15). Ganglion gasseri, ganglia of VII and IX-X and auditory vesicles are normal. In sum, the noticeable features of this type are the fused olfactory plates, two, small eye cups, absence of lenses and undifferentiated cornea.

Type III. In this type two examples are cited. The specimen of Fig. 7 measures 11 mm. in length and 2 mm. in width. The external features look like Type II. Olfactory plates fuse at the anterior end of the body. In section the fusion of the olfactory plates of a high degree is observed. And, moreover, the eye cup is a single block of ellipsoidal form, which is in the median line at the ventral side of

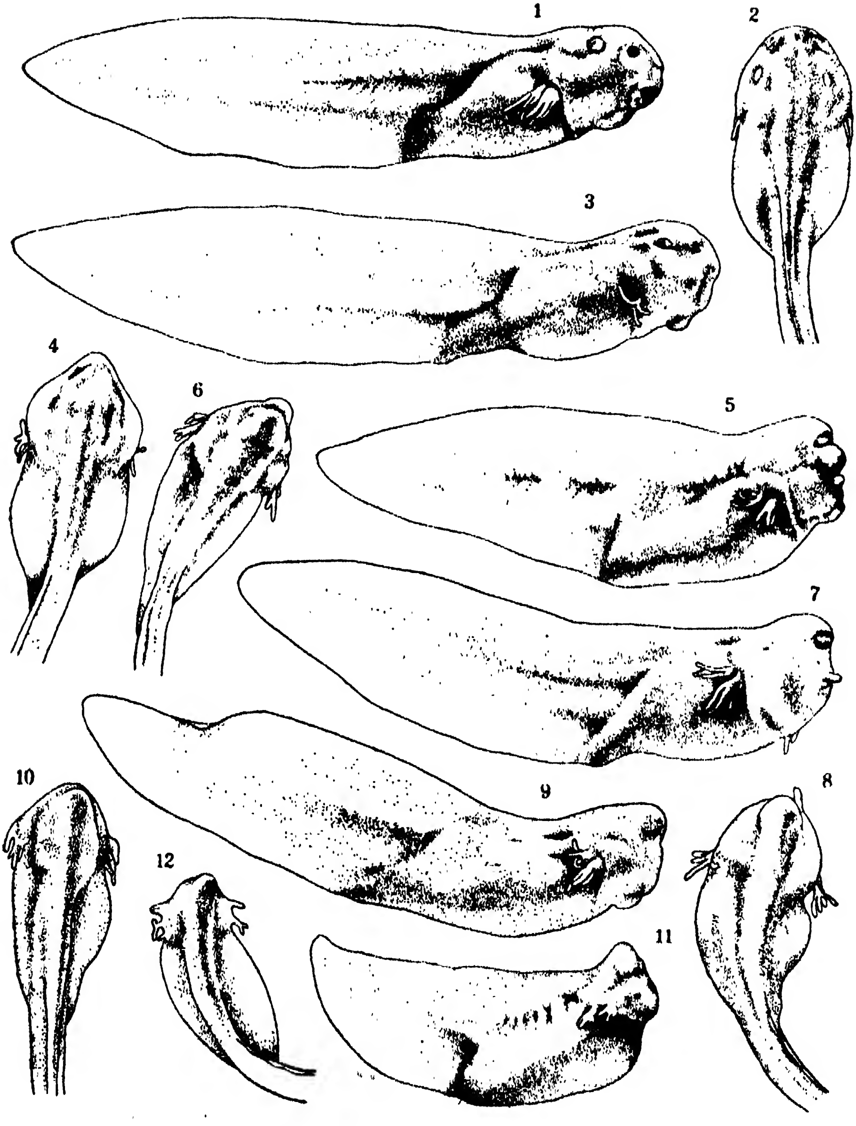

Fig. 1. side view of a normal embryo, six days old. Fig. 2. dorsal view of the same embryo. Figs. 3, 5, 7, 9 and 11. side views of the centrifuged embryos. Figs. 4, 6, 8, 10 and 12. dorsal views of the same embryos as in Figs. 3, 5, 7, 9 and 11 respectively.

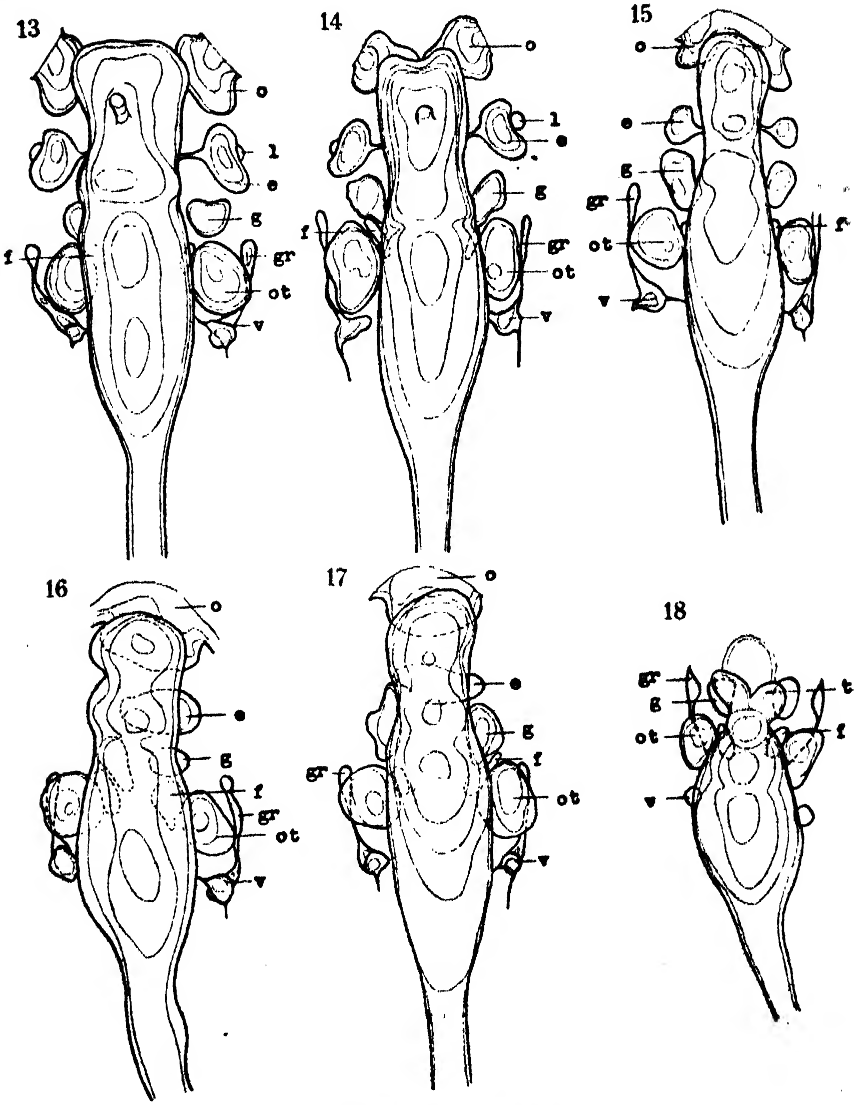

Fig. 13. dorsal view of the central nervous system of the normal embryo, six days old, reconstructed from the frontal sections. Figs. 14, 15, 16, 17 and 18. dorsal views of the central nervous system of the same specimens as in Figs. 3, 5, 7, 9 and 11 respectively.

e—eye cup. f—ganglion of 7th cranial nerve. g—ganglion gasseri. gr—ganglion of 9th cranial nerve. v—ganglion of 10th cranial nerve. l—lens. o—olfactory plate. ot—auditory vesicle. t—telencephalon.

the brain (Fig. 16). The histological features of this eye cup are normal and show the differentiation of the retinal layer and the pigment layer in spite of its irregular outline. This eye cup lies very far from the epidermis of the head; the lens is not formed. This is a sort of cyclopia not furnished with a lens. Auditory vesicles, ganglia gasseri, ganglia of VII and IX-X are present. Other features and structures are normal. The specimen of Figure 9 measures 11 mm. in length and 1.8 mm. in width. Anterior end of this specimen is smooth. Olfactory pit, buccal cavity, sucker and cornea have all disappeared, but the features of the external gills of both sides and the more posterior portion of the body are normal. In section (Fig. 17) there is a thickening of the ectoderm at the anterior end of the head, notwithstanding the absence of invagination of the olfactory pit. This structure is an olfactory plate fused as in the former cases. A single eye cup is formed at the ventral side of the brain. This eye cup shows the histological structures of the normal retinal layer and a pigment layer. But there is no lens as in the former specimen of this type. Auditory vesicles, ganglia gasseri, ganglia of VII and of IX-X are present. Other structures are normal.

In this type the fusion of the olfactory plates and the formation of the single eye cup are the remarkable features. But this type of cyclopia is wanting in the lens and cornea, and is not possible of detection from the outward appearance. In both specimens the ganglia of the cranial nerves do not show the deformation, but they slip down slightly to the ventral side of the neural tube. Fusion of the ganglia at the ventral median line was not observed.

Type IV. The specimen which is shown in Figs. 11, 12 and 18 is an example of this type. Body measures 6 mm. in length and 1.7 mm. in width. The development of every part is delayed. But the blastopore closure is complete and the embryo dose not show signs of *spina bifida.* The face is smooth. Olfactory pit, buccal cavity, sucker and cornea are not observed. The head portion of this embryo is so small that the external gills are only a short distance from the tip of the head (Figs. 11 and 12). The deformation of the central nervous system is very intense. The olfactory plate and eye cup are not visible, and the telencephalon remains rudimentally only as a bilobated diffused cell mass. Diencephalon and mesencephalon

are very small, but rhombencephalon is, on the contrary, of nearly normal size. The ganglion gasseri, auditory vesicles, ganglia of VII and of X of the cranial nerves show normal structures but they are only a little smaller than in the normal stage. A pair of ganglia are observed at the antero-ventral side of the auditory vesicles. These ganglia are probably the ganglia IX separated from the ganglia X. Pronephros and heart are normal.

Specimens of the Type IV are relatively small in size. And in many cases the tail is bent and twisted. Yolk mass is scattered among the mesodermal tissues. After all the absence of olfactory plate and eye cup and the degeneration of the prosencephalon and the mesencephalon are the most noticeable features of this type.

The results of the observations are summarized as follows: The effect of the centrifugal force appears to a different extent according to the individuals. In a mild case the olfactory plates approach the median line. In the next place the fusion of the olfactory plates and the missing of the lens occur. And in the more extreme cases only one eye cup is formed at the ventral median line of the neural tube, instead of one at each sides. In the most extreme case olfactory plate and eye cup are missing, and the atrophie of the prosencephalon and mesencephalon occurs. But, in my cases, other ganglia of the cranial nerves and sense organs remain normal, except for a slight displacement of the ganglia to the ventral median line. Atrophie of the epidermal structures, cornea, sucker and buccal cavity occurs always parallel to the distortion of the central nervous system.

DISCUSSION.

In my previous paper ('30) I reported on the presumptive position and the orientation of the medullary material in the frog's egg (*Rhacophorus*). The results were nearly like those in VOGT's observation ('29) on Bombinator and other europian species of the frog. Comparing the deformations mentioned above with the embryonal maps of VOGT's and of my paper it is noticed that the deformations begin at first at the animal pole of the egg and then advance gradually to the lower portions. This corresponds to the deformations from the mild case of Type I to the heavily suffered form of Type IV. In

other words, the centrifugal force destroys the organ forming materials from the animal pole. This is the same conclusion obtained by JENKINSON ('14).

Many authors have pointed out that in the eggs of other animals, for example in *Arbacia* and in *Cumingia*, the polarity of the embryo which has developed from the centrifuged egg is not related to the polarity of the stratification of the visible materials which is caused by the centrifugal force (MORGAN '27). This is a suggestion of presence of the "Metastruktur" (GURWITSCH '30) in the egg cytoplasm; that is, a promorphological or organforming structure in the "pure" cytoplasm of the egg. In my observation, there is no room for doubt that in the frog's egg a certain proportion between the cytoplasm and the "grobes" material is nessesary for the normal process of the organformation. The deformation of my cases is a sign of distortion of the valance between the cytoplasm and the "grobes" material. And it is a reserved problem, whether there is also the "Metastruktur" in the cytoplasm of the amphibian egg besides the "grobe" structure or not. Upon the evidence of this problem I can not touch from my observations.

SUMMARY.

The effects of centrifugal force in the Japanese frog's egg, *Rana japonica* GÜNTHER were studied.

A tendency of the deformation in the centrifuged embryos, which have passed the gastrulation stage without developing into ring embryos or spina bifida was described.

The effects of the centrifugal force which is applied to the fertilized egg before the first cleavage appear on the organs of the animal pole of the egg in a mild case and, if the effect is greater, extend to the organs of the lower portion of their presumptive position.

Sendai, March 8th, 1931.

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Untersuchungen über die osmotischen Werte bei Pflanzen auf dem Berg Hakkôda.[1]

VON

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(Eingegangen am 9. April 1931)

Trotz der grossen Anzahl von Arbeiten über den osmotischen Wert gibt es noch wenige, die sich mit der Konzentration des Zellsafts verschiedener Pflanzentypen eines beschränkten Gebiets vom ökologischen Gesichtspunkt aus beschäftigt haben. FITTING (1911)[2] war der erste, der eine enge Beziehung zwischen dem osmotischen Wert einer Pflanze und ihrem Standort festgestellt hat. Dann wurde von einigen Forschern die Anpassungsfähigkeit der Hochgebirgspflanzen an das Alpenklima durch Veränderung der Höhe des osmotischen Werts beobachtet, an der aber MAXIMOW[3] im Jahre 1917 zweifelte. Neuerdings haben nun sogar einige Ökologen ihre Ansicht dahin ausgesprochen, dass die als ökologisches Merkmal angesehene Konzentration des Zellsafts vielmehr als ein charakteristisches, konstitutionelles Merkmal aufzufassen ist. Das Problem der Zellsaftkonzentration zusammen mit der Saugkraft einer Pflanze hat erst dann eine grosse ökologische Bedeutung, wenn es mit der Wasserabgabe der Pflanze im Zusammenhang steht, und wird dabei auch wichtig für die Wasserökonomie der Pflanzen unter extremen Standortsverhältnissen.

Obwohl wir uns in vorliegender Arbeit hauptsächlich mit dem osmotischen Wert der Gebirgspflanzen beschäftigen, so wollen wir damit doch auch eine sichere Grundlage für die sehr verwickelte Frage des Wasserhaushalts der Gebirgspflanzen schaffen, worauf wir in einem in Bälde zu veröffentlichenden Transpirationsversuche mit diesen Gebirgspflanzen noch zurückkommen werden.

Vorliegende Versuche wurden im neu gegründeten botanischen

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1) Contributions from the Mt. Hakkôda Botanical Laboratory. No. 7.

2) FITTING, H., Zeitschr. f. Botan. Bd. 3, S. 209. 1911.

3) MAXIMOW, N. A., Arb. d. Tifliser Bot. Gart. Bd. 19, S. 195. 1917.

Laboratorium auf dem Berg Hakkôda im Juli 1929 ausgeführt, und die untersuchten Pflanzen wurden sowohl in der Umgebung des Laboratoriums wie auf dem Gipfel des Gebirges, auf Grasmooren und im Strauchgebiet gesammelt. Es wurden daher viele Gebirgspflanzen geprüft, die an ökologisch ganz uneinheitlichen Orten gewachsen waren und auch systematisch zu mannigfaltigen Ordnungen gehören.

Wenn der osmotische Wert einer Pflanze, wie später auseinandergesetzt werden wird, schon an demselben Standort und zu gleicher Zeit stark differenzieren kann, so ist beim Vergleiche der Pflanzen von verschiedenen Standorten besondere Vorsicht geboten; wie bekannt, verändert sich die Zellsaftkonzentration der meisten Pflanzen zeitlich, je nach der Tageszeit. Das beruht hauptsächlich auf dem zeitlichen Wechsel des Wasserverhältnisses der Pflanze. Die Pflanzen sind im allgemeinen morgens im Turgorzustande und mit Wasser gesättigt; ferner zeigten einige vorläufige Versuche, dass die Schwankungen des osmotischen Werts, wenn sie überhaupt erfolgen, am Morgen sehr gering sind. Der osmotische Wert des Zellsafts scheint bei jeder Pflanzenart am Morgen normal zu sein; dies weist u. E. auch wieder darauf hin, dass sich die konstitutionelle Zellsaftkonzentration der Pflanze nur am Morgen wirklich zeigt. Deshalb haben wir das Material immer nur am Morgen gesammelt, um die Veränderung der osmotischen Eigenschaften infolge der Tageszeit möglichst zu vermeiden. Das Material wurde gleich nach der Sammlung im Laboratorium untersucht und sogar das auf dem Gipfel gesammelte spätestens binnen einigen Stunden behandelt. Als plasmolysierenden Stoff benutzten wir Rohrzucker. Die Lösungen wurden mit Intervallen von 0.1 Grammol bereitet. Als plasmolytische Grenzkonzentration wurde die minimale Konzentration genommen, bei der sich eine geringe Loslösung des Plasmas von den Wänden beobachten liess. Die Schnitte wurden von der oberen Epidermis eines vollständig entwickelten Blatts genommen, zunächst etwa eine halbe Stunde lang in der Lösung belassen und dann zum Versuche gebracht.

Der Berg Hakkôda, auf dem das Laboratorium gebaut wurde, liegt auf der Nordspitze unserer Hauptinsel Hondo, 40°50′ n. B. Unter dem Einfluss einer kalten Meeresströmung ist das Klima von Nord-Japan im Verhältnis zu seinem geographischen Breitengrad ziemlich kalt. Zur Charakterisierung der Witterungsverhältnisse geben wir

zunächst das Monatsmittel der Temperaturen, der relativen Feuchtigkeit und die monatlichen Niederschläge nach den amtlichen Berichten der meteorologischen Station in Aomori, einer Stadt, die am Fuss unseres Bergs, etwa 20 km vom Laboratorium entfernt liegt.

TABELLE 1.

	Jan.	Feb.	März	Apr.	Mai	Juni	Juli	Aug.	Sep.	Okt.	Nov.	Dez.	Jahr
Temperatur (°C.)	-2.6	-2.2	0.7	7.1	11.8	16.3	20.8	22.9	18.6	12.1	6.0	0.1	9.3
Niederschläge (mm)	155	114	91	64	72	81	139	113	141	119	142	169	1400
Feuchtigkeit (%)	81	78	74	72	74	79	82	81	79	76	76	79	77

Da der Berg in einem kalten Gebiet liegt, hat er sehr kaltes Klima, sodass er trotz seiner geringen Höhe eine grosse Anzahl von Hochgebirgspflanzen liefert. Die meteorologischen Daten auf dem Gipfel sind zur Zeit noch nicht hinreichend, um daraufhin dem Berge Alpenklima zuzusprechen; jedoch können wir das eine anführen, dass die Schneemenge im Winter gewöhnlich äusserst gross ist und der Gipfel wenigstens zwei Drittel des ganzen Jahres mit Schnee bedeckt ist und die Umgebung des Laboratoriums sogar 7 Monate, von Anfang November bis zum Ende Mai, unter Schnee bleibt. Der Berg Hakkôda ist ein Vulkan-Massiv mit vielen Gipfeln und einigen alten Kratern, die jetzt im Solfatarenzustande sind. In allernächster Nähe des Laboratoriums befindet sich ein alter Krater, ein Schlammkessel, in dessen Tiefe noch eine graublaue, breiige, flüssige Masse brodelt und aus dem fortwährend Dämpfe und schweflige Gase ausströmen. Der Berg Ôdake hat den höchsten Gipfel, der 1580 m ü. M. emporragt und in der Mitte des Massivs liegt. Mit ihm sind zwei hohe Berge, Akakura und Ido, nach Norden hin durch eine Kette verbunden. In senkrechter Richtung steigen im Osten noch andere höhere Vulkane, Kodake und Takadaôdake, empor. In diesem Vulkan-Massiv trifft man ökologisch uneinheitliche Bestände mit abweichender Topographie und Vegetation an; z. B. Grasmoore, Sümpfe, Alpenrasen, Wälder, Strauchbüsche, Humarolen, heisse Quellen, Kraterböden, Geröllabhänge

usw. Das ganze Gebiet des Bergs kann daher als ein grosses Versuchsfeld betrachtet werden. Eine ausführliche Beschreibung der einzelnen Vegetationen wird hier nicht gegeben, da sie erst neuerdings von unserem Mitarbeiter Dr. HORIKAWA (1930)[1] in dieser Zeitschrift veröffentlicht worden ist. Im Folgenden wird die Vegetation nur gelegentlich behandelt, soweit sie nämlich zu dem eingesammelten Material Beziehung hat.

Das Laboratorium steht 900 m ü. M. auf dem südwestlichen Abhang des Kegels Ôdake in weitgehend unberührtem *Sasa*buschwerk, am Rand eines alten Kraters. Die Vegetation dieser Höhenstufe müsste eigentlich die obere Stufe des *Fagetum* sein, doch herrscht infolge des spezifischen edaphischen Verhältnisses der Solfataren eine Vegetation von fast undurchdringlichem *Sasa*busch vor. Mit *Sasa kurilensis* gemischt sind viele Sträucher, wie *Ilex Sugeroki* subsp. *brevipedunculata*, *Rhododendron brachycarpum*, und ausserdem durch Schneelasten klein gebliebene Bäume, wie *Fagus Sieboldi*, *Abies Mariesii* und *Betula Ermanii*, var. *communis*. Die Eu-Chamaephyten-Gesellschaft von *Sasa kurilensis* erinnert an die Zwergstrauchheide des europäischen Alpengebiets. In stark schattenden Gebüschen tritt viel schattenliebender Unterwuchs auf. Die Vegetation der Solfataren ist anderseits dadurch ausgezeichnet, dass eine grosse Anzahl von Hochgebirgspflanzen auftritt, die gewöhnlich nur oberhalb der Alpenrasenstufe wachsen. Eine ähnliche merkwürdige Erscheinung hat FABER (1927)[2] bei Vulkanen in Java beobachtet.

Auf unserem Berg kommt *Abietum* öfters unmittelbar oberhalb von *Fagetum* vor, während sich üppige und reine *Pinus*-Assoziation überall an den oberen Abhängen findet. Diese Assoziation dehnt sich weiter oben sogar bis zum Kraterrand am Gipfel aus, und hier ist der Boden ausschliesslich mit diesen Sträuchern bedeckt. Auf dem verwitterten Boden des Kraterrandes, sowie auf den in lebhafter Verwitterung begriffenen Abhängen trifft man eine schöne Assoziation von Zwergsträuchern, mit anderen kleinen Hochgebirgspflanzen gemischt, während auf dem alten, seichten Kraterboden eine verhältnismässig spärliche Gesellschaft auftritt. Eine deutlich einheitliche Vegetation

1) HORIKAWA, Y., Science Reports Tôhoku Imp. Univ. 4th Ser. (Biol.) Vol. 5, p. 555. 1930.

2) FABER, F. C. von, Die Kraterpflanzen Javas. Buitenzorg. 1927.

zeigt das Grasmoor, das sich auf vulkanischer Aschenschicht entwickelt. Zwei weit ausgedehnte Moore liegen übereinander in Terrassen an einem Abhange des Ôdake. Sie zeichnen sich dadurch aus, dass es auf ihnen eine grosse Anzahl kleiner verstreuter, dicht beieinander liegender Teiche gibt. Auf diesem nassen Moorland, besonders an den Teichen, treten viele Moorpflanzen auf. Davon haben wir in einer anderem Abhandlung ausführlich gesprochen (YOSHII und HAYÁSI 1931[1]).

Im folgenden seien zunächst die von uns ermittelten osmotischen Werte für 18 Hochgebirgspflanzen auf dem Gipfel zusammengefasst.

TABELLE 2.

	Osmotischer Wert
Veratrum nigrum var. *japonicum*	0.3
Salix Reinii	0.3
Alnus alnobetula var. *fruticosa*	0.5
Polygonum Weyrichii	0.3
Aquilegia akitensis	0.4
Clematis alpina	0.6
Ranunculus acris var. *Steveni*	0.3
Sedum Rhodiola var. *elongatum*	0.2
Parnassia palustris	0.3
Fragaria Iinumae	0.3
Potentilla Matsumurae	0.5
Spiraea betulifolia	0.5
Hypericum kamtschaticum	0.5
Pentastemon frutescens	0.3
Pinguicula vulgaris	0.3
Campanula lasiocarpa	0.5
Anaphalis margaritacea	0.3
Arnica unalaschensis	0.4
Durchschnitt	0.38 ± 0.11

Wie aus obiger Tabelle ersichtlich, besitzen diese auf sonnigem

[1] YOSHII, Y. und HAYASI, N., Science Reports Tôhoku Imp. Univ. 4th Ser. (Biol.) Vol. 6, p. 307. 1931.

Gelände wachsenden Pflanzen keinen besonders hohen osmotischen Wert, da er durchschnittlich dem Druck von 0.38 Mol Rohrzucker entspricht. In Atmosphären ausgedrückt, beträgt er also nur rund 10 Atm. Für die einzelnen Pflanzenarten schwankt der osmotische Wert von 0.2 bis zu 0.6 Mol. Diese Tatsache, dass die Hochgebirgspflanzen niedrige Konzentration des Zellsafts besitzen, stimmt vollständig mit den Befunden von MAXIMOW (1923)[1], BLAGOWESTSCHENSKI (1926)[2], URSPRUNG und BLUM (1916)[3] überein. Ob dieser geringe osmotische Wert unserer Hochgebirgspflanzen auf die günstigen Wasserverhältnisse bei Hochgebirgspflanzen, wie BLAGOWESTSCHENSKI (1928)[4] meint, zurückzuführen ist, bleibt noch unklar. Gelegentliche Untersuchungen des Wassergehalts der Hochgebirgserde zeigen im allgemeinen keine besonders hohe Bodenfeuchtigkeit. Ausserdem weichen die von uns ermittelten osmotischen Werte je nach ihrem Standort nur sehr wenig voneinander ab. Besonders sei bemerkt, dass auf stark ausgetrocknetem Felströmmergeröll wachsende Pflanzen, wie *Aquilegia akitensis* (0.4)[5], *Pentastemon frutescens* (0.3), *Anaphalis margaritacea* (0.3) und *Potentilla Matsumurae* (0.5), auch geringe und annähernd gleiche Konzentration besitzen wie die auf dem humushaltigen Kraterrand wachsenden Pflanzen, wie *Veratrum nigrum* var. *japonicum* (0.3), *Hypericum kamtschaticum* (0.5), und *Arnica unalaschensis* (0.4). Der niedrigste osmotische Wert von 0.2 Mol wurde bei *Sedum Rhodiola* var. *elongatum* gefunden. Dass Sukkulenten eine niedrige Zellsaftkonzentration besitzen, wurde schon von vielen Forschern bei Pflanzen auf extremen Gebieten bemerkt.

Der Abhang des Bergs in der Nähe des Gipfels bildet ein felsiges Bergland mit Felströmmergeröll. Infolge starker Exposition und Steile ist das Gelände immer ausgetrocknet, und es können dort nur solche Pflanzen gut wachsen, die Dürre gut ertragen können. *Pinus pumila*, eine Hochgebirgskiefer in der Strauchstufe unserer Hochgebirge, verbreitet sich mit kriechenden Zweigen auf den ausgedehnten Abhängen. Das xeromorphe Blatt dieser Kiefer besitzt den hohen osmo-

[1] MAXIMOW, N. A., Jahrb. f. wiss. Botan. Bd. 62, S. 128, 1923.
[2] BLAGOWESTSCHENSKI, A. W., Jahrb. f. wiss. Botan. Bd. 65, S. 279, 1926.
[3] URSPRUNG, A. und BLUM, G., Ber. d. deutsch. botan. Gesell. Bd. 34, S. 125. 1916.
[4] BLAGOWESTSCHENSKI, A. W., Jahrb. f. wiss. Botan. Bd. 69, S. 191. 1928.
[5] Die Angaben in Klammern zeigen den osmotischen Wert der betreffenden Pflanze.

tischen Wert von 0.8 Mol. Am West- und Südabhang, wo die Austrocknung stärker ist, herrschen Polster von *Loiseleuria procumbens* (0.9), *Diapensia lapponica* var. *asiatica* (0.8) und *Empetrum nigrum* (0.9) vor, und dazwischen stehen verstreut einzelne Vertreter von *Andromeda nana* (0.5) und *Vaccinium Vitis-Idaea* (0.8).

TABELLE 3.

	Osmotischer Wert
Pinus pumila	0.8
Empetrum nigrum	0.9
Ilex rugosa	0.6
Andromeda nana	0.5
Loiseleuria procumbens	0.9
Vaccinium Vitis-Idaea	0.8
Diapensia lapponica var. *asiatica*	0.8
Durchschnitt	0.76±0.14

Diese Sträucher mit xeromorpher Struktur treten auf äusserst ausgetrocknetem Boden auf, sind starker Sonnenbestrahlung ausgesetzt und zeichnen sich durch lederige, stark reduzierte Blättchen aus. Die mittlere plasmolytische Konzentration, die bei sieben Xerophyten ermittelt wurde, ist hoch und beträgt 0.76 Mol; sie schwankt zwischen 0.5 und 0.9 Mol (Tabelle 3). Dieser Wert ist höher als der der Gipfelpflanzen.

Zwischen dieser Alpensträucher-Gesellschaft und der darunter liegenden *Sasa*-Gesellschaft kommen verschiedene, uneinheitliche Gesellschaften auf dem ausgedehnten, sonnigen, ausgetrockneten Abhang vor. Die Zellsaftkonzentration der Pflanzen dieser Gesellschaft ist im folgenden zussammengefasst (Tabelle 4).

Der durchschnittliche osmotische Wert dieser 16 mesophytischen Gebirgspflanzen beträgt 0.39 Mol (zwischen 0.2 und 0.6 Mol). Dieser Wert ist niedriger als der der xerophytischen Sträucher, aber dem der Gipfelpflanzen annähernd gleich.

Kurz, die Hochgebirgspflanzen umfassen eine Anzahl ökologisch uneinheitlicher Pflanzen, obwohl sie alle auf demselben sonnigen Gebiet wachsen. Die bei diesen sämtlichen Lichtpflanzen (41 Arten) ermittelte

TABELLE 4.

	Osmotischer Wert
Blechnum nipponicum	0.3
Orchis aristata	0.3
Platanthera sachalinensis	0.2
Fagus Sieboldi	0.4
Akebia lobata	0.4
Diphylleia Grayi	0.3
Schizophragma hydrangeoides	0.4
Tiarella polyphylla	0.4
Prunus nipponica	0.6
Acer spicatum var. *ukurunduense*	0.6
Viola Selkirkii	0.3
Viola verecunda var. *typica*	0.5
Carum holopetalum	0.4
Peracarpa carnosa	0.3
Eupatorium sachalinense	0.4
Lactuca dentata var. *Thunbergii*	0.5
Durchschnitt	0.39 ± 0.11

Zellsaftkonzentration ist keineswegs hoch, ihr osmotischer Wert entspricht einem Druck von 0.45 Mol Zuckerlösung. Der hohe osmotische Wert xeromorpher Sträucher ist in ihrer konstitutionellen Eigenschaft zu suchen, wovon später noch weiter die Rede sein wird. Wir können daher keine unmittelbare Beziehung zwischen der Zellsaftkonzentration und dem Standort der Gipfelpflanzen feststellen, soweit es ihren minimalen, osmotischen Wert betrifft.

Von 143 erforschten Pflanzen gehören 32 Arten zu den Schattenbewohnern, die nicht nur an Standorten von verschiedener Meereshöhe, sondern auch an Stellen gefunden werden, die unter ganz verschiedenen edaphischen Bedingungen stehen. Die meisten Schattenpflanzen wachsen aber in der stark schattenden *Sasa*-Gesellschaft, die sich auf der Gebirgsmittelstufe üppig entwickelt. Mitten in ihr steht, wie oben erwähnt, unser Laboratorium. Mit dem *Sasa*-Strauch bilden viele andere Sträucher einen dicht zusammen gewachsenen Bestand, dessen Inneres nur Lichtgenuss von 1/100–1/150 geniesst. Man trifft jedoch

üppige Untervegetation an. Während einige Pflanzen lediglich im stark schattenden *Sasa*busche gut gedeihen, können die meisten Schattenbewohner auch auf wenig beschattetem Bestand wachsen, und Pflanzen, wie *Platanthera ophrydioides*, *Orchis aristata*, *Aletris foliata*, *Lilium Maximowiczii*, *Veratrum stamineum*, *Petasites japonicus* var. *giganteus* u. a. können sogar auf belichteten Stellen auftreten, wenn der Boden nass genug ist. Es handelt sich in den meisten Fällen mehr um das Wasserverhältnis des Standorts als um das Lichtverhältnis, ob eine schattenliebende Pflanze an einem Ort fortkommt oder nicht, worauf schon WALTER (1928)[1] hingewiesen hat. Dass die Bodenfeuchtigkeit von allen äusseren Faktoren an erster Stelle auf den osmotischen Wert wirkt, ist von vielen Forschern festgestellt worden. Ein diesbezügliches, bemerkenswertes Beispiel wurde von URSPRUNG und BLUM (1916)[2] gegeben. Eine Pflanze zeigte in der Ebene auf sonnigem Felsen 114 Atm., aber auf schattigem, feuchtem Felsen nur 54 Atm. Diese auffallende Abweichung im osmotischen Wert ist ganz auf die Verschiedenheit der Wasserversorgung zurückzuführen. Das Wasserverhältnis an schattigen und an feuchten Orten ist für Pflanzen ökologisch ganz ähnlich, da sie weder hohe Saugkraft der Zellen, noch besondere Entwicklung der unterirdischen Organe zum Saugen brauchen. Sie haben ganz einheitlich niedrigen osmotischen Wert, wie aus folgender Tabelle zu ersehen ist.

TABELLE 5.

	Osmotischer Wert
Dryopteris mutica	0.3
Plagiogyria Matsumuraeana	0.5
Clintonia udensis	0.2
Heloniopsis breviscapa	0.5
Maianthemum bifolium	0.3
Paris tetraphylla	0.4
Smilacina japonica	0.2
Smilax Oldhami	0.4
Streptopus ajanensis var. *japonica*	0.3

[1] WALTER, H., Jahrb. f. wiss. Botan. Bd. 68, S. 233. 1928.
[2] URSPRUNG, A. und BLUM, G., l. c.

	Osmotischer Wert
Streptopus amplexifolius	0.3
Trillium apetalon	0.4
Listera cordata	0.4
Platanthera ophrydioides	0.3
Platanthera sachalinensis	0.2
Asarum Sieboldi	0.3
Coptis trifolia	0.3
Glaucidium palmatum	0.4
Ranunculus hakkodensis	0.3
Trautvetteri palmata var. *japonica*	0.3
Diphylleia Grayi	0.3
Schizophragma hydrangeoides	0.4
Tiarella polyphylla	0.4
Oxalis Acetosella var. *japonica*	0.4
Viola brevistipulata	0.3
Echinopanax horridus	0.3
Monotropa uniflora	0.3
Trientalis europaea	0.4
Crawfurdia trinervis	0.4
Pinguicula vulgaris	0.3
Galium kamtschaticum var. *oreganum*	0.3
Galium trifidum	0.3
Peracarpa carnosa	0.3
Durchschnitt	0.33±0.07

Der bei 32 Schattenpflanzen von verschiedenen Standorten ermittelte, durchschnittliche osmotische Wert beträgt nur 0.33 Mol (zwischen 0.2 bis 0.5 Mol). Die geringe quadratische Abweichung des mittleren Werts bedeutet gutes Anpassungsvermögen dieser Schattenbewohner.

Im Anschluss an Schattenpflanzen behandeln wir kurz den osmotischen Wert auf feuchten, jedoch sonnigen Grasmooren wachsender Pflanzen. Obwohl die Moore auf voneinander entfernten Stellen in verschiedener Meereshöhe liegen, ist gemäss dem einheitlichen Standortsverhältnis die Vegetation stets ähnlich. Die Pflanzen auf diesen nassen Grasmooren wachsen üppig, sind aber artenarm und zeigen ein

einfaches Aussehen. Wir haben im ganzen 15 Pflanzen untersucht; die mit ihnen erzielten Resultate seien in der folgenden Tabelle zusammengefasst.

TABELLE 6.

	Osmotischer Wert
Lysichiton camtschatense	0.3
Hosta japonica var. *angustifolia*	0.3
Narthecium asiaticum	0.3
Veratrum stamineum	0.4
Drosera rotundifolia	0.3
Saxifraga cortusaefolia var. *typica* f. *rosea*	0.3
Geum pentapetalum	0.4
Sanguisorba tenuifolia var. *alba*	0.4
Angelica Yabeana	0.4
Oxycoccus palustris var. *intermedium*	0.4
Primula nipponica	0.3
Fauria Crista-galli	0.4
Lobelia sessilifolia	0.3
Inula ciliaris	0.3
Ligularia calthaefolia	0.4
Durchschnitt	0.35 ± 0.05

Der mittlere osmotische Wert beträgt nur 0.35 Mol mit einer Abweichung von 0.3 bis 0.4 Mol. Daraus lässt sich erkennen, dass die Lichtpflanzen auf nassem Boden auch geringen osmotischen Wert haben, ebenso wie eine Pflanze von Ericaceae (*Oxycoccus palustris* var. *intermedium*) auf durchnässtem Moorboden. Wie später auseinandergesetzt werden wird, haben die meisten Ericaceae-Pflanzen sonst einen hohen osmotischen Wert. Dasselbe Verhältnis lässt sich auch bei Rosaceae auf nassem Bestand erkennen: *Geum pentapetalum* (0.4) und *Sanguisorba tenuifolia* var. *alba* (0.4) besitzen in gleicher Weise niedrigen osmotischen Wert, während die anderen verwandten Arten, wie *Potentilla Matsumurae* (0.5) und *Rubus spectabilis* subsp. *vernus* (0.7) auf nicht stark durchnässtem Bestand höheren osmotischen Wert haben. Daraus ist zu ersehen, dass Pflanzen mit niedrigem osmotischem Wert die Tendenz haben, auf feuchten Boden einzudringen. Eine

andere deutliche Verschiedenheit im osmotischen Wert je nach dem Standort lässt sich bei einander nahe stehenden Arten erkennen; *Vaccinium Vitis-Idaea* (0.8) kommt an etwas trocknen Orten vor, während *Oxycoccus palustris* var. *intermedium* (0.4) nur auf nassen Stellen wächst. Der geringere osmotische Wert auf feuchtem Bestand wachsender Pflanzen, wie *Lobelia sessilifolia* (0.3), als der auf ausgetrocknetem Steingeröll entwickelten Pflanzen, wie *Campanula lasiocarpa* (0.5), ist als Beispiel der Anpassung anzusehen. Das zeigt, dass eine enge Beziehung zwischen dem Wasserverhältnis des Bodens und dem osmotischen Wert der Pflanzen besteht, die auf sonnigem, aber durchnässtem Boden vorkommen. Die Pflanzen in solchem Bestand brauchen keine starke Saugkraft, weil der Transpirationsverlust ihrer Mengen durch beständige Zufuhr von Wasser im Boden wieder gedeckt wird. Sie könnten sonst den starken sonnigen und trocknen Sommer nicht überstehen. Ein ganz ähnliches Verhältnis wurde auch bei xeromorphen Pflanzen festgestellt. Pflanzen wie *Shortia soldanelloides* var. *genuina* (0.4), *Ledum palustre* var. *nipponicum* (0.4) und *Phyllodoce aleutica* (0.4) besitzen Zellsaft mit deutlich niedrigerer Konzentration im Verhältnis zu anderen Xerophyten. Dabei sei bemerkt, dass diese Pflanzen gewöhnlich auf feuchten Böden auftreten. Ungeachtet ihres Standortes zeigen xeromorphe Pflanzen im allgemeinen hohen osmotischen Wert, der durchschnittlich 0.8 Mol Rohrzucker entspricht, nämlich etwa 26 Atmosphären Druck (vgl. auch Tab. 3). Der xeromorphe Zwergstrauch *Skimmia japonica* (0.7) besitzt trotz seiner schattenliebenden Eigenschaft im Vergleich mit anderen Schattenpflanzen (vgl. Tab. 5) ziemlich hohen osmotischen Wert. Eine Schattenpflanze, *Ilex rugosa* (0.6), ist ein weiteres Beispiel dafür. Sie hat aber einen noch niedrigeren osmotischen Wert als ein systematisch ihr nahe stehender xeromorpher Strauch, *Ilex Sugeroki*, subsp. *brevipedunculata*, dessen osmotischer Wert 0.8 Mol beträgt. Ein ähnliches Verhältnis lässt sich auch bei Pflanzen auf nassem Boden erkennen. *Rhododendron glabrius*, das gewöhnlich auf Moorböden auftritt, besitzt verhältnismässig hohen osmotischen Wert (0.7).

Diese Tatsache, zusammen mit dem hohen osmotischen Wert gemeiner Bäume auf Standorten verschiedener edaphischer Verhältnisse, trieb noch zu weiteren Studien über den osmotischen Wert je nach den Lebensformen der Pflanzen. Diese Verschiedenheit des osmotischen

Werts je nach den Lebensformen wurde schon von verschiedenen Forschern bemerkt. Unter anderem haben HARRIS und LAWRENCE (1917)[1] auf Grund ihrer Ergebnisse bei 136 von ihnen untersuchten Bergpflanzen im Regenwald darauf hingewiesen, dass die mittlere Konzentration des Zellsafts der Bäume etwa 23–30% höher ist als die der Kräuter. Das von BLAGOWESTSCHENSKI (1928)[2] bei Hochgebirgspflanzen gefundene Resultat bestätigt diese Tatsache auch. Im folgenden werden die osmotischen Werte aller erforschten Pflanzen je nach den Lebensformen zusammengefasst (Tabelle 7), um die Beziehung zwischen den Lebensformen und dem osmotischen Wert festzustellen.

TABELLE 7.

Lebensform	Anzahl der erforschten Arten	Durchschnitt der osmotischen Werte
Mega- und Mesophanerophyten (MM)	11	0.60
Mikrophanerophyten (M)	12	0.58
Nanophanerophyten (N)	14	0.53
Chamaephyten (Ch)	15	0.65
Hemikryptophyten (H)	60	0.37
Geophyten (G)	26	0.36
Helo- und Hydrophyten (HH)	4	0.33
Therophyten (Th)	1	0.30

Den höchsten osmotischen Wert zeigen die Chamaephyten, zu denen die meisten unserer Hochgebirgspflanzen gehören. In der Höhe der Zellsaftkonzentration folgt dann eine Reihe von Mega- und Mesophanerophyten, danach Mikrophanerophyten und Nanophanerophyten, während Geophyten und Hemikryptophyten einen deutlich geringeren Wert zeigen. In unserem Falle ist die Abweichung der Zellsaftkonzentration noch viel ausgeprägter als die von HARRIS und anderen Forschern bei Bäumen und Kräutern auf Hochgebirgen festgestellte,

[1] HARRIS, J. A. and LAWRENCE, J. V., Amer. Jour. of Botan. Vol. 4, p. 268. 1917.
[2] BLAGOWESTSCHENSKI, A. W., l. c.

und zwar ist die Konzentration der ersten etwa 55% grösser als die der zweiten (Tabelle 8).

TABELLE 8.

Osmotischer Wert / Lebensform	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	Gesamtzahl	Durchschnitt der osmotischen Werte
Bäume und Zwergbäume[1]	0	5 (2)	9 (4)	9 (4)	7 (3)	8 (3)	5 (3)	3 (2)	2 (1)	48 (22)	0.59 (0.61)
Kräuter	5	42	29	13	4	1	1	0	0	95	0.38
Gesamte Pflanzen	5	47	38	22	11	9	6	3	2	143	0.45

Offenbar muss man diese auffallende Abweichung der Zellsaftkonzentration nicht nur auf die Anpassungsfähigkeit der Pflanzen, sondern auch auf die spezifischen konstitutionellen Eigenschaften der Pflanzen zurückführen. Nun können wir einige unserer Beispiele dagegen geben. Pflanzen, die an demselben Standort wachsen und ganz gleiche Lebensformen besitzen, haben ganz verschiedenen osmotischen Wert. *Loiseleuria procumbens*, eine typische xeromorphe Hochgebirgspflanze, bildet auf dem Abhang des Bergs das gleiche Polster wie *Andromeda nana*. Die beiden Zwergsträucher wachsen üppig nebeneinander auf sonnigem Geröll. Während der erste einen hohen osmotischen Wert (0.9 Mol) besitzt, hat der andere einen niedrigen (0.5 Mol). Anderseits besitzt eine Reihe von Pflanzen, z. B., Aceraceae und Rosaceae, die keine morphologisch ausgeprägte, xeromorphe Eigenschaft aufweisen, hohen osmotischen Wert. Anderseits zeigen zu den gleichen systematischen Abteilungen gehörende Pflanzen von verschiedenen Standorten annähernd gleichen osmotischen Wert, z. B. Pinaceae. In der Tat kam BLAGOWESTSCHENSKI (1926)[2] auf Grund von Zahlen, die er selbst und auch viele andere Forscher beobachteten, zu dem Schluss, dass innerhalb der einzelnen Familien eine gewisse Tendenz besteht, die Arten um einige in der betreffenden Familie am häufigsten

[1] Einschliesslich einer Liane.
Die Ziffern in Klammern zeigen die Anzahl der Zwergbäume.
[2] BLAGOWESTSCHENSKI, A. W., l. c.

vorkommende osmotische Werte zu gruppieren; und zwar lassen sich einzelne Familien und Gattungen durch eine bestimmte, ihnen eigene Höhe dieses Werts charakterisieren, wobei der Einfluss äusserer Faktoren gewöhnlich von ganz untergeordneter Bedeutung ist. Um festzustellen, ob diese Ansicht von BLAGOWESTSCHENSKI auch für unsere Fälle gilt, wurden die osmotischen Werte aller von uns untersuchter Pflanzen nach den Familien gruppiert. Im ganzen gehören die von uns untersuchten 143 Pflanzen zu 30 Familien, doch enthalten die meisten Familien eine zu ungenügende Anzahl von Vertretern, um daraus ihre charakteristische Eigenschaft erkennen zu können. Daher werden im folgenden nur solche Familien miteinander verglichen, die wenigstens 3 Vertreter haben.

TABELLE 9.

Osmotischer Wert / Familien	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	Gesamtzahl	Durchschnitt der osmotischen Werte
Polypodiaceae		2		1	1					4	0.43 ± 0.13
Pinaceae						1	1		1	3	0.83 ± 0.13
Liliaceae	2	6	6	1						15	0.34 ± 0.08
Orchidaceae	1	2	1							4	$0.30+0.07$
Ranunculaceae		4	2		1					7	0.37 ± 0.10
Saxifragaceae		3	2							5	0.34 ± 0.05
Rosaceae		1	3	3	1	2		1		11	0.54 ± 0.17
Aceraceae					2	3				5	0.66 ± 0.05
Violaceae		2		1						3	0.37 ± 0.09
Araliaceae		2	1							3	0.33 ± 0.05
Umbelliferae		1	3							4	0.38 ± 0.04
Ericaceae		1	5	3	2	2	3	1	1	18	0.59 ± 0.21
Gentianaceae		1	2	1						4	0.40 ± 0.07
Campanulaceae		2	1	1						4	0.38 ± 0.08
Compositae		5	3	3						11	0.38 ± 0.08

Aus der Tabelle kann man zunächst erkennen, dass sich die osmotischen Werte je nach den einzelnen Familien mehr oder weniger gesetzmässig verteilen. Wie oben erwähnt, beträgt der mittlere osmotische Wert aller untersuchter Pflanzen 0.45 Mol (vgl. Tab. 8) bei einer Abweichung von 0.2 bis 1.0 Mol. Die höchste Konzentration des

Zellsafts, 0.83 Mol, zeigten Pinaceae, denen Aceraceae mit 0.66 Mol und Ericaceae mit 0.59 Mol folgten. Während die 5 Vertreter der Aceraceae alle zu den Bäumen gehören, enthalten Ericaceae 18 Vertreter von Sträuchern. Bei der Familie Ericaceae variieren die osmotischen Werte in ziemlich weiten Grenzen, da sie die mittlere Konzentration von 0.59 Mol besitzt und die mittlere quadratische Abweichung ziemlich gross ist (± 0.21). Eine geringe Konzentration besitzen dagegen Araliaceae, Saxifragaceae und Liliaceae und die geringste die Orchidaceae. Diese Ergebnisse stimmen mit den von BLAGOWESTSCHENSKI mitgeteilten Resultaten gut überein. Er hat weiter darauf hingewiesen, dass die Vertreter solcher Familien wie Liliaceae, Amaryllidaceae und Iridaceae einen geringen osmotischen Wert besitzen, aber dass ihr unterirdischer Wasserbehälter fast dieselbe Rolle spielt wie die fleischigen Blätter bei den Sukkulenten. Diese seine Ansicht konnten wir bei unseren Pflanzen auch vollauf bestätigen, insofern Liliaceae und Orchidaceae geringe Konzentration des Zellsafts zeigten. Zweifellos können diese Pflanzen, wenn ihre Saugkraft auch gering ist, mit ihrem Wasserbehälter die Dürre gut ertragen, wie das andere durch üppige Entwicklung ihrer Wurzeln taten.

Obwohl unsere Ergebnisse offenbar eine enge Beziehung zwischen dem osmotischen Wert und der Verwandtschaft der Pflanzen zeigen, so dürfen wir doch auch die Anpassungsfähigkeit der Pflanzen, die je nach ihrer Art ganz verschieden sein muss, nicht ausser acht lassen. Die Tatsache, dass Pflanzen mit ganz verschiedenen osmotischen Werten nebeneinander auf vollständig gleichem Standort wachsen, war die andere Hauptgrundlage der BLAGOWESTSCHENSKIschen Ansicht. Diese Beziehung lässt sich auch bei unseren Pflanzen deutlich zeigen, jedoch muss anderseits die Tatsache berücksichtigt werden, dass zwei systematisch ganz verschiedene Pflanzen auf ein und demselben Standort fast den gleichen osmotischen Wert besitzen. Das lässt sich bei Pflanzen auf nassem Grasmoore besonders ausgeprägt beobachten, wofür oben Beispiele gebracht wurden. Nach unserer Meinung muss daher der osmotische Wert der Pflanzen sowohl als konstitutionelles Merkmal als auch als Anpassungsmerkmal betrachtet werden; die Plastizität des osmotischen Werts, der sich durch eine Stichprobe nicht genau erkennen lässt, bleibt offenbar noch weiter zu erforschen.

Die Frage nun, wie die Hochgebirgspflanzen auf sonnigem Gebiet

sich gegen starke Trockenheit erhalten können, lässt sich nur nach eingehender Erforschung ihrer Wasserbilanz zur Zeit der Trockenheit entscheiden. Im Gegensatz zu der von alters her vertretenen Ansicht, dass Pflanzen auf trockenem Standort die Einrichtung, ihre Transpiration einzuschränken, besitzen, haben neuerdings viele Forscher, unter denen MAXIMOW (1924)[1] und STOCKER (1924)[2] zu nennen sind, festgestellt, dass xerophytische Sonnenpflanzen von verschiedenen Standorten ebenso wie, oder sogar noch stärker als mesophytische Schattenpflanzen transpirieren. Unser Resultat bei den Transpirationsversuchen mit Hochgebirgspflanzen, über die später in einer anderen Abhandlung berichtet werden wird, stimmt im grossen und ganzen mit diesem Befunde gut überein. Wenn schon die Hochgebirgspflanzen stark transpirieren, dann müssen sie auch zur Zeit der Trockenheit lebhaft Wasser aufnehmen. Durch welche Vorrichtungen können sich dann diese Pflanzen, die mit schwacher Saugkraft versehen sind, zur Dürrezeit so viel Wasser beschaffen? Dies ist ein wichtiges ökologisches Problem, das noch der Klärung harrt. Der Gedanke, dass die Pflanzen die schädlichen Folgen des Welkens zur Zeit der Trockenheit durch die starke Saugkraft der Zellen ertragen und überwinden, gilt wahrscheinlich nicht hier. Viele Forscher haben gefunden, der osmotische Wert der Hochgebirgspflanzen sei keineswegs besonders hoch. Das wurde auch bei unseren Pflanzen bestätigt, und zwar war ihre Saugkraft nicht gross genug, um dadurch ihr Bestehen während der Dürrezeit zu erklären. Die Ansicht von BLAGOWESTSCHENSKI, dass die günstigen Wasserverhältnisse im Hochgebirgsboden dabei eine grosse Rolle spielen dürften, gilt in unseren Fällen nicht immer, wie schon oben erwähnt. Unserer Meinung nach müssen dabei wenigstens zweierlei Einrichtungen der Pflanzen in solch sonnigem Gebiete berücksichtigt werden. Zunächst die Plastizität der Zellsaftkonzentration einer Pflanze. Bekanntlich vermögen die meisten Pflanzen ihre Zellsaftkonzentration zusammen mit dem Wassergehalt des Bodens zu verändern. Für die Anpassungsfähigkeit der Pflanzen an ihre ökologischen Verhältnisse muss man zunächst den Wechsel des osmotischen Werts je nach dem Standort bei jeder Pflanzenart näher erforschen.

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[1] MAXIMOW, N. A. and KRASNOSELSKY-MAXIMOW, T. A., Jour. of Ecol. Vol. 12, p. 95. 1924.

[2] STOCKER, O., Zeitschr. f. Botan. Bd. 16, S. 289. 1924.

Oder, in zweiter Linie, kann die Wasserversorgung der Hochgebirgspflanzen durch ein ausgedehntes Wurzelsystem, einschliesslich Wasserbehälter, erzielt werden. Dies ist auch ein wichtiges Problem für die Wasserökonomie der Hochgebirgspflanzen, das aber zur Zeit nur wenig berücksichtigt wird, jedenfalls bei Hochgebirgspflanzen.

ZUSAMMENFASSUNG.

1) Wir behandelten in vorliegender Abhandlung die osmotischen Werte der Gebirgspflanzen. Die Versuche wurden an 143 Arten ausgeführt, die an ökologisch uneinheitlichen Orten auf dem Berg Hakkôda wachsen und auch zu verschiedenen systematischen Ordnungen gehören.

2) Der osmotische Wert von Hochgebirgspflanzen, einschliesslich den auf stark ausgetrocknetem Felstrümmergeröll wachsenden, ist nicht hoch. Er entspricht durchschnittlich nur dem Druck einer Rohrzuckerlösung von etwa 0.4 Mol (Tabelle 2).

3) Xeromorphe Pflanzen auf der Strauchstufe des Bergs besitzen aber im grossen und ganzen einen höheren osmotischen Wert, der durchschnittlich etwa 0.8 Mol beträgt (Tabelle 3).

4) Auf der Mittelstufe des Bergs trifft man ganz einheitliche Vegetation an, die hauptsächlich aus Mesophyten besteht. Sie besitzen annähernd den gleichen niedrigen Wert wie die auf dem Gipfel (Tabelle 4).

5) Die meisten Schattenpflanzen kommen im stark schattenden *Sasa*-Gebüsche vor. Sie haben ganz einheitlich niedrigen osmotischen Wert von etwa 0.3 Mol (Tabelle 5). Die auf feuchtem, aber sonnigem Grasmoor wachsenden Pflanzen besitzen auch eine niedrige Zellsaftkonzentration (Tabelle 6).

6) Die Pflanzen auf durchnässtem Bestand zeigen im allgemeinen geringere Zellsaftkonzentration als die anderen verwandten, auf ausgetrocknetem Boden vorkommenden. Daraus ist zu ersehen, dass eine Beziehung zwischen dem osmotischen Wert einer Pflanze und ihrem Standort besteht. Ferner haben Pflanzen mit niedrigem osmotischem Wert die Tendenz, in feuchten Boden einzudringen.

7) Anderseits ist aber eine Verschiedenheit des osmotischen Werts je nach den Lebensformen zu erkennen. Der höchste osmotische

Wert zeigt sich bei Chamaephyten, dann folgt eine Reihe von Mega- und Mesophanerophyten und ihnen wieder Mikrophanerophyten und Nanophanerophyten, während Hemikryptophyten und Geophyten einen geringeren Wert haben. Damit zusammen lässt sich erkennen, dass Bäume im allgemeinen stark höheren osmotischen Wert als Kräuter besitzen (Tabelle 7 und 8).

8) Der osmotische Wert verteilt sich nach den einzelnen Familien mehr oder weniger gesetzmässig. Die höchste Konzentration des Zellsafts zeigten Pinaceae, dann folgten Aceraceae und Ericaceae. Mit BLAGOWESTSCHENSKIs Ergebnissen übereinstimmend, haben auch bei uns die Vertreter von Liliaceae und Orchidaceae, die unterirdische Organe als Wasserbehälter besitzen, einen geringen Wert (Tabelle 9).

9) Es gibt aber Pflanzen, die gleiche Lebensformen besitzen oder zu derselben Familie gehören und dennoch ganz verschiedenen osmotischen Wert zeigen. Anderseits haben wieder systematisch zu verschiedenen Abteilungen gehörende Pflanzen auf demselben Bestand einen annähernd gleichen osmotischen Wert. Der osmotische Wert der Gebirgspflanzen ist also teils als konstitutionelles, teils als Anpassungsmerkmal zu betrachten.

10) Kurz, der osmotische Wert der Hochgebirgspflanzen ist im allgemeinen so niedrig, dass man damit die starke Saukgraft der Zellen nicht erklären kann. Die Frage, wie sie sich auf sonnigem Gebiet, wo starke Transpiration erfolgt, gegen starke Trockenheit erhalten können, ist heute noch schwer zu beantworten. Nach unserer Meinung beruht die Lebensfähigkeit der Pflanzen im Gebirgsklima, wenigstens soweit sie die Wasserökonomie betrifft, auf einer von den zwei Einrichtungen, entweder auf der Plastizität der Konzentration des Zellsafts je nach dem Standort oder auf der Wasserversorgung ihres ausgedehnten Wurzelsystems, einschliesslich seines Wasserbehälters.

OSMOTISCHER WERT DER ERFORSCHTEN PFLANZEN.

Polypodiaceae	Osmotischer Wert	Lebensform
1. *Blechnum nipponicum* Makino. (しシがしら)	0.3	G
2. *Dryopteris mutica* C. Chr. (しのぶかぐま)	0.3	G

3. *Plagiogyria Matsumuraeana* Makino. (やまそてつ)	0.5	G
4. *Pteridium aquilinum* Kuhn. (わらび)	0.6	G
Osmundaceae		
5. *Osmunda cinnamomea* L. (やまどりしだ)	0.5	G
6. *Osmunda regalis* L. var. *japonica* Milde. (ぜんまい)	0.6	G
Pinaceae		
7. *Abies Mariesii* Mast. (おおしらびそ)	1.0	MM
8. *Larix leptolepis* Gord. (からまつ)	0.7	MM
9. *Pinus pumila* Regel. (はいまつ)	0.8	N
Sparganiaceae		
10. *Sparganium glomeratum* Laest. (こみくり)	0.2	HH
Gramineae		
11. *Sasa kurilensis* Makino et Shibata. (ねまがりだけ)	0.6	Ch
Araceae		
12. *Lysichiton camtschatense* Schott. (みづばせう)	0.3	HH
Liliaceae		
13. *Aletris foliata* Franch. (ねばりのぎらん)	0.4	G
14. *Clintonia udensis* Trautv. et Mey. (つばめおもと)	0.2	G
15. *Heloniopsis breviscapa* Maxim. (しゃうじゃうばかま)	0.5	G
16. *Hosta japonica* Aschers. et Graebn. var. *angustifolia* Aschers. et Graebn. (みづぎばうし)	0.3	G
17. *Lilium Maximowiczii* Regel. (こおにゆり)	0.4	G
18. *Maianthemum bifolium* DC. (まひづるさう)	0.3	G
19. *Narthecium asiaticum* Maxim. (きんこうくわ)	0.3	G
20. *Paris tetraphylla* A. Gray. (つくばねさう)	0.4	G
21. *Smilacina japonica* A. Gray. (ゆきざさ)	0.2	G
22. *Smilax Oldhami* Miq. (たちしほで)	0.4	G
23. *Streptopus ajanensis* Tiling. var. *japonica* Maxim. (たけしまらん)	0.3	G
24. *Streptopus amplexifolius* DC. (おほばたけしまらん)	0.3	G
25. *Trillium apetalon* Makino. (えんれいさう)	0.4	G
26. *Veratrum nigrum* L. var. *japonicum* Bak. (しゅろさう)	0.3	G
27. *Veratrum stamineum* Maxim. (こばいけいさう)	0.4	G
Orchidaceae		
28 *Listera cordata* R. Br. (ふたばらん)	0.4	G
29. *Orchis aristata* Fisch. (はくさんちどり)	0.3	G

30. *Platanthera ophrydioides* Fr. Schm. (きそちどり)	0.3	G
31. *Platanthera sachalinensis* Fr. Schm. (おほやまさぎさう)	0.2	G
Salicaceae		
32. *Salix Reinii* Franch. et Sav. (みやまやなぎ)	0.3	N
Betulaceae		
33. *Alnus alnobetula* Hartig. var. *fruticosa* Winkl. (みやまはんのき)	0.5	M
34. *Betula Ermanii* Cham. var. *communis* Koidz. (だけかんば)	0.5	MM
Fagaceae		
35. *Fagus Sieboldi* Endl. (ぶなのき)	0.4	MM
Aristolochiaceae		
36. *Asarum Sieboldi* Miq. (うすばさいしん)	0.3	G
Polygonaceae		
37. *Polygonum sachalinense* Fr. Schm. (おほいたどり)	0.4	H
38. *Polygonum Weyrichii* Fr. Schm. (うらじろたで)	0.3	H
Nymphaeaceae		
39. *Nymphaea tetragona* Georgi. var. *angusta* Casp. subv. *orientalis* Casp. (ひつじぐさ)	0.5	HH
Ranunculaceae		
40. *Aquilegia akitensis* Huth. (みやまをだまき)	0.4	H
41. *Clematis alpina* Mill. (みやまはんしやうづる)	0.6	H
42. *Coptis trifolia* Salisb. (みつばわうれん)	0.3	H
43. *Glaucidium palmatum* Sieb. et Zucc. (しらねあふひ)	0.4	H
44. *Ranunculus acris* L. var. *Steveni* Regel. (みやまきんばうげ)	0.3	H
45. *Ranunculus hakkodensis* Nakai. (つるきつねのぼたん)	0.3	H
46. *Trautvetteri palmata* Fisch. et. Mey. var. *japònica* Huth. (もみぢからまつ)	0.3	H
Lardizabalaceae		
47. *Akebia lobata* Decne. (みつばあけび)	0.4	Ch
Berberidaceae		
48. *Diphylleia Grayi* Fr. Schm. (さんかえふ)	0.3	H
Magnoliaceae		
49. *Magnolia hypoleuca* Sieb. et Zucc. (ほほのき)	0.3	MM
Lauraceae		
50. *Lindera umbellata* Thunb. (くろもじ)	0.4	N
Droseraceae		
51. *Drosera rotundifolia* L. (まうせんごけ)	0.3	H

Crassulaceae		
52. *Sedum Rhodiola* DC. var. *elongatum* Maxim. (ほそばいはべんけい)	0.2	H
Saxifragaceae		
53. *Hydrangea paniculata* Sieb. (のりうつぎ)	0.3	N
54. *Parnassia palustris* L. (うめばちさう)	0.3	H
55. *Saxifraga cortusaefolia* Sieb. et Zucc. var. *typica* Makino f. *rosea* Makino. (あかばなだいもんじさう)	0.3	H
56. *Schizophragma hydrangeoides* Sieb. et Zucc. (いはがらみ)	0.4	H
57. *Tiarella polyphylla* D. Don. (づだやくしゆ)	0.4	H
Hamamelidaceae		
58. *Hamamelis japonica* Sieb. et Zucc. (まんさく)	0.6	M
Rosaceae		
59. *Aruncus silvester* Kostel. var. *americanus* Maxim. (やまぶきしょうま)	0.5	H
60. *Filipendula kamtschatica* Maxim. (おにしもつけ)	0.4	H
61. *Fragaria Iinumae* Makino. (のうごいちご)	0.3	H
62. *Geum pentapetalum* Makino. (ちんぐるま)	0.4	H
63. *Potentilla Matsumurae* Wolf. (みやまきんばい)	0.5	H
64. *Prunus Grayana* Maxim. (うはみづざくら)	0.7	MM
65. *Prunus nipponica* Matsum. (たかねざくら)	0.6	MM
66. *Rubus spectabilis* Pursh. subsp. *vernus* Focke. (べにばないちご)	0.7	N
67. *Sanguisorba tenuifolia* Fisch. var. *alba* Trautv. et Mey. (ながばのしろわれもかう)	0.4	H
68. *Sorbus Aucuparia* L. (ななかまど)	0.9	M
69. *Spiraea betulifolia* Pall. (まるばしもつけ)	0.5	Ch
Oxalidaceae		
70. *Oxalis Acetosella* L. var. *japonica* Makino. (みやまかたばみ)	0.4	H
Rutaceae		
71. *Skimmia japonica* Thunb. (みやましきみ)	0.7	N
Euphorbiaceae		
72. *Daphniphyllum humile* Maxim. (えぞゆづりは)	0.5	N
Empetraceae		
73. *Empetrum nigrum L.* (がんかうらん)	0.9	Ch
Anacardiaceae		
74. *Rhus silvestris* Sieb. et Zucc. (やまはぜ)	0.5	M

Aquifoliaceae		
75. *Ilex rugosa* Fr. Schm. (つるつげ)	0.6	Ch
76. *Ilex Sugeroki* Maxim. subsp. *brevipedunculata* Makino. (あかみのいぬつげ)	0.8	M
Aceraceae		
77. *Acer japonicum* Thunb. var. *typicum* Graf. v. Schw. (はうちはかへで)	0.7	MM
78. *Acer pictum* Thunb. var. *typicum* Graf. v. Schw. subv. *eupictum* Pax. (いたやかへで)	0.6	MM
79. *Acer spicatum* Lam. var. *ukurunduense* Maxim. (をがらばな)	0.6	MM
80. *Acer tenuifolium* Koidz. (ひなうちはかへで)	0.7	M
81. *Acer Tschonoskii* Maxim. (みねかへで)	0.7	M
Guttiferae		
82. *Hypericum kamtschaticum* Ledeb. (いはおとぎり)	0.5	H
Violaceae		
83. *Viola brevistipulata* W. Beck. (おほばきすみれ)	0.3	H
84. *Viola Selkirkii* Pursh. (みやますみれ)	0.3	H
85. *Viola verecunda* A. Gray. var. *typica* Makino. (つぼすみれ)	0.5	H
Araliaceae		
86. *Aralia cordata* Thunb. (うど)	0.3	H
87. *Echinopanax horridus* Decne. et Planch. (はりぶき)	0.3	H
88. *Kalopanax sciadophylloides* Harms. (こしあぶら)	0.4	M
Umbelliferae		
89. *Angelica Yabeana* Makino. (おほばせんきう)	0.4	H
90. *Carum holopetalum* Maxim. (いぶきぜり)	0.4	H
91. *Cnidium ajanense* Drude. (しらねにんじん)	0.3	H
92. *Peucedanum multivittatum* Maxim. (はくさんばうふう)	0.4	H
Cornaceae		
93. *Cornus canadensis* L. (ごぜんたちばな)	0.3	H
94. *Cornus controversa* Hemsl. (みづき)	0.5	MM
Pirolaceae		
95. *Monotropa uniflora* L. (ぎんりゃうさう)	0.3	Th
Ericaceae		
96. *Andromeda nana* Makino. (こめばつがざくら)	0.5	Ch
97. *Diplycosia adenothrix* Nakai. (あかもの)	0.7	Ch
98. *Epigaea asiatica* Maxim. (いはなし)	0.8	Ch

99. *Gaultheria Miqueliana* Takeda. (しらたまのき)	1.0	Ch
100. *Ledum palustre* L. var. *nipponicum* Nakai. (いそつつじ)	0.4	Ch
101. *Leucothoe Grayana* Maxim. var. *Maximowicziana* Takeda. (おほはなひりのき)	0.5	N
102. *Loiseleuria procumbens* Desv. (みねづはう)	0.9	Ch
103. *Menziesia ciliicalyx* Maxim. var. *multiflora* Makino. (うらじろやうらく)	0.5	N
104. *Menziesia pentandra* Maxim. (こやうらくつゝじ)	0.4	N
105. *Oxycoccus palustris* Pers. var. *intermedium* A. Gray. (つるこけもも)	0.4	Ch
106. *Phyllodoce aleutica* A. A. Heller. (あをのつがざくら)	0.4	Ch
107. *Rhododendron Albrechtii* Maxim. (むらさきやしほつつじ)	0.3	M
108. *Rhododendron brachycarpum* D. Don. (しろばなしやくなげ)	0.8	M
109. *Rhododendron glabrius* Nakai. (れんげつつじ)	0.7	N
110. *Tripetaleia paniculata* Sieb. et Zucc. (ほつつじ)	0.6	N
111. *Vaccinium ciliatum* Thunb. (なつはぜ)	0.4	N
112. *Vaccinium hirtum* Thunb. var. *Smalli* Maxim. (おほばすのき)	0.6	N
113. *Vaccinium Vitis-Idaea* L. (こけもも)	0.8	Ch
Diapensiaceae		
114. *Diapensia lapponica* L. var. *asiatica* Herd. (いはうめ)	0.8	Ch
115. *Shortia soldanelloides* Makino var. *genuina* Makino f. *typica* Makino. (いはかがみ)	0.4	H
Primulaceae		
116. *Primula nipponica* Yatabe. (ひなざくら)	0.3	H
117. *Trientalis europaea* L. (つまとりさう)	0.4	H
Gentianaceae		
118. *Crawfurdia trinervis* Makino. (つるりんだう)	0.4	H
119. *Fauria Crista-galli* Makino. (いはいてふ)	0.4	H
120. *Gentiana nipponica* Maxim. (みやまりんだう)	0.5	H
121. *Menyanthes trifoliata* L. (みつがしは)	0.3	HH
Scrophulariaceae		
122. *Pedicularis japonica* Miq. (よつばしほがま)	0.4	H
123. *Pentastemon frutescens* Lamb. (いはぶくろ)	0.3	H
Lentibulariaceae		
124. *Pinguicula vulgaris* L. (むしとりすみれ)	0.3	H
Rubiaceae		

125. *Galium kamtschaticum* Stell. var. *oreganum* Piper. (おほばのよつばむぐら)	0.3	H
126. *Galium trifidum* L. (ほそばのよつばむぐら)	0.3	H
Caprifoliaceae		
127. *Diervilla joponica* DC. (たにうつぎ)	0.3	M
128. *Viburnum furcatum* Blume. (むしかり)	0.4	M
Campanulaceae		
129. *Campanula lasiocarpa* Cham. (いはぎきゃう)	0.5	H
130. *Codonopsis lanceolata* Benth. et Hook. f. (つるにんじん)	0.4	H
131. *Lobelia sessilifolia* Lamb. (さはぎきゃう)	0.3	H
132. *Peracarpa carnosa* Hook. f. et Thoms. (たにぎきゃう)	0.3	H
Compositae		
133. *Anaphalis margaritacea* Benth. et Hook. f. (やまははこ)	0.3	H
134. *Arnica unalaschensis* Less. (うさぎぎく)	0.4	H
135. *Aster Glehni* Fr. Schm. (ごまな)	0.5	H
136. *Cirsium oligophyllum* Matsum. (ひとつばあざみ)	0.3	H
137. *Eupatorium sachalinense* Makino. (よつばひよどりばな)	0.4	H
138. *Inula ciliaris* Maxim. (みづぎく)	0.3	H
139. *Lactuca dentata* Makino. var. *albiflora* Makino. (しろばなにがな)	0.3	H
140. *Lactuca dentata* Makino var. *Thunbergii* Makino. (にがな)	0.5	H
141. *Ligularia calthaefolia* Maxim. (たからかう)	0.4	H
142. *Petasites japonicus* Miq. var. *giganteus* Makino. (あきたぶき)	0.5	H
143. *Solidago Virgaurea* L. (あきのきりんさう)	0.3	H

On the Daily Fluctuation of the Osmotic Value in Plants.[1)]

By

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(With 4 text-figures)

INTRODUCTION

In the preceding paper (8), Professor YOSHII and the writer reported their investigation on the osmotic values of a number of alpine plants on Mt. Hakkôda, and, besides some other results, pointed out that the osmotic value of alpine plants is to be regarded as partly an adaptive characteristic and partly a constitutional characteristic.

At the suggestion of Professor YOSHII, the writer intended to investigate further the modes of fluctuation of the osmotic value in each plant. In the present paper the daily fluctuation is principally treated of.

A regular daily fluctuation of the osmotic value has already been recognized in various plants by URSPRUNG and BLUM (6), BLAGOWESTSCHENSKI (2) and WALTER (7).

According to those authors the osmotic value generally sinks to the minimum in the early morning and, by gradual increase, reaches the maximum in the afternoon, after which it decreases toward the next morning. The minimum value generally amounts to more than 80 per cent. of the maximum.

However, it has not yet been determined how far the mode of the daily fluctuation is affected by climatic conditions. As is well known from a number of investigations by ILJIN, NAZAROVA and OSTROVSKAJA (5), HARRIS and LAWRENCE (3, 4), BLAGOWESTSCHENSKI (1, 2), WALTER (7), etc., the moisture of the soil and the atmosphere strikingly affect the osmotic value and, in consequence, the latter is

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1) Contributions from the Mt. Hakkôda Botanical Laboratory. No. 8.

changed by climatic conditions in the same plant — the more humid are the climatic conditions, the more the osmotic value decreases. It is, therefore, probable that there exist some relations between the mode of the daily fluctuation and the climatic changes day by day.

The present investigation was conducted with special reference to this problem.

MATERIALS AND METHODS

The writer investigated several species of plants growing by the Mt. Hakkôda Botanical Laboratory in the summers of the years 1929 and 1930.

The osmotic value was determined by means of plasmolysis in the epidermal cells of the upper side of mature leaves. As the plasmolyzing solution, saccharose solutions of various volume-molecular concentrations were used with a difference of 0.05 (in the experiments of 1929) or 0.025 (in those of 1930) in the unit. The osmotic value is indicated by the volume-molecular concentration of the weakest saccharose solution in which plasmolysis takes place.

RESULTS

During the periods of the experiments some climatic factors were observed in the Laboratory as are represented in the figures (figs. 1–4).

Duration of sunshine was determined by a JORDAN sunshine recorder.

Temperature and relative humidity were obtained by taking the mean of hourly readings from a thermo-hygrograph.

Wind velocity was estimated by a wind scale[1].

Evaporation was determined by a LIVINGSTON spherical atmometer.

The results obtained for each plant are shown in the following tables, in which each number indicates the osmotic value for an individual leaf.

For the same species of plant, individuals growing close to each other were chosen as material for the experiment, leaves from about the same height being used.

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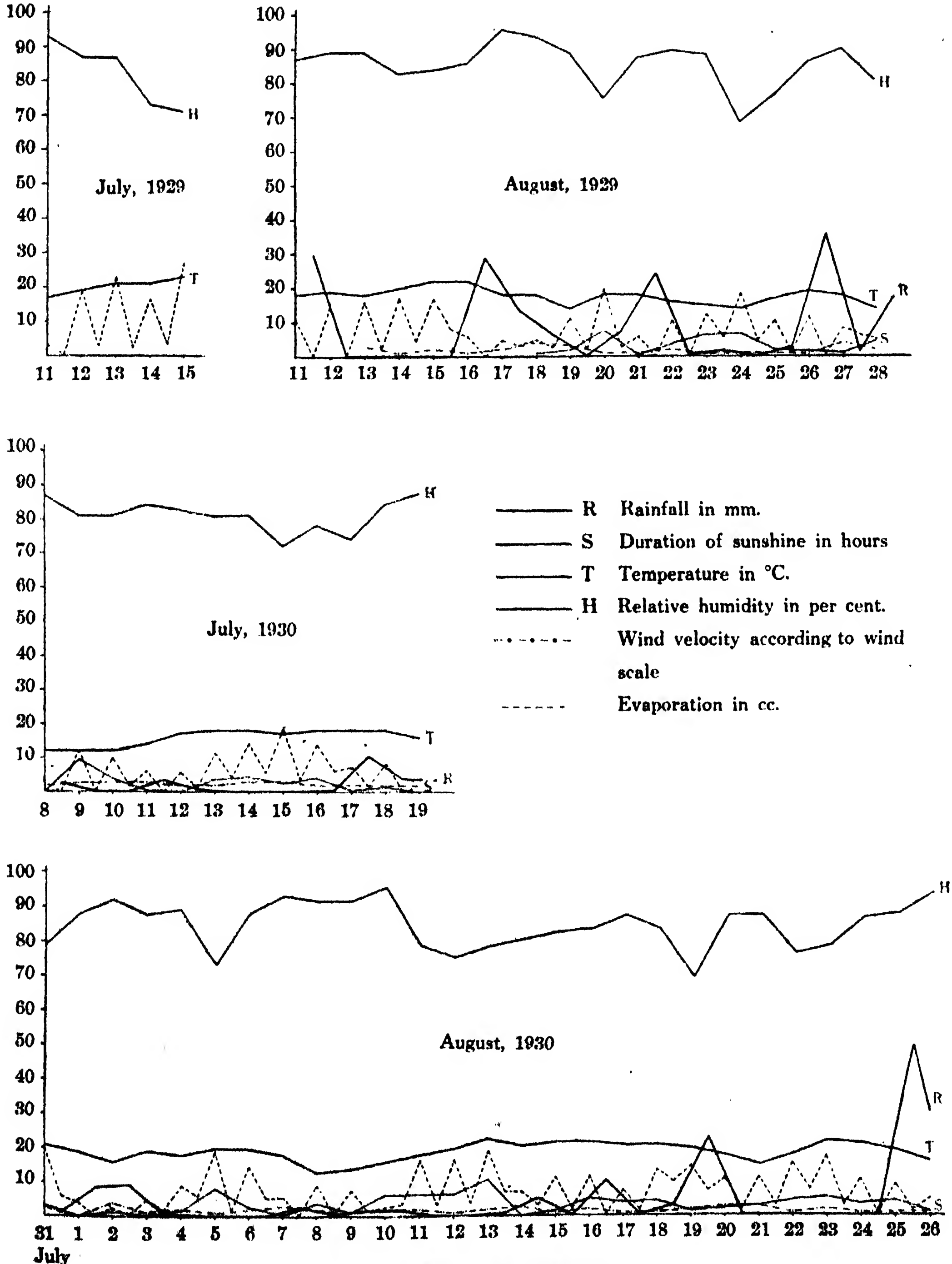
[1] Cf. OKADA, T., Meteorology. 1927. p. 140.



Figs. 1–4. Climatic Factors.

Results in 1929.

1. *Paris tetraphylla* A. Gray. (Liliaceae)

Date	Weather[1]	Evaporation[1]	General climatic conditions	Plant-individual	Osmotic value		
					8 a. m.	1 p. m.	5 p. m.
August 16	Cloudy-rainy	6 cc.	Arid-humid (after fine days)	No. 1	0.4	0.4	0.4
				No. 2	0.35	0.35	0.35
				No. 3	0.4	0.4	0.4
				No. 4	0.35	0.4	0.4
				Mean	**0.375**	**0.388**	**0.388**

2. *Polygonum sachalinense* Fr. Schm. (Polygonaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Shoot[2]	Osmotic value		
						8 a. m.	1 p. m.	5 p. m.
July 14	Fair	17 cc.	Becoming arid (after rain)	No. 1	No. 1	0.35 0.35		0.4
					No. 2	0.35		
				No. 2		0.35 0.35		0.35
				No. 3				0.4
				Mean		**0.35**		**0.383**
July 15	Fair	27	Arid	No. 4		0.35	0.4	0.4
				No. 5		0.4	0.4	0.4
				No. 6		0.45	0.45	0.45
				Mean		**0.4**	**0.417**	**0.417**

---

1) "Weather" denotes that of the daytime, "Evaporation" that during the time from 7 a. m. to 7 p. m.

2) When nothing about the number of the shoot is described, it means one shoot in each individual.

Date	Weather	Evaporation	General climatic conditions	Plant individual	Shoot	Osmotic value		
						8 a. m.	1 p. m.	5 p. m.
		cc.						
August 18	Rainy-cloudy	5	Humid	No. 7	No. 1	0.35 0.4	0.35 0.35	0.35 0.35
				No. 8		0.4 0.4	0.35 0.4	0.45 0.45
				No. 9		0.45 0.45	0.4 0.4	0.4 0.4
				No. 10		0.4 0.4	0.35 0.45	0.4 0.5
				Mean		**0.406**	**0.381**	**0.413**
August 19	Cloudy	11	Becoming arid (after rain)	No. 7	No. 2	0 4 0.4	0.4 0.45	0.45 0.45
				No. 8		0.4 0.4	0.45 0.45	0.45 0.5
				Mean		**0.4**	**0.438**	**0.463**
August 20	Fair, with rain at 4 p. m.	20	Arid	No. 7	No. 3	0.45 0.45	0.45 0.45	0.4 0.45
				No. 8		0.4 0.4	0.4 0.45	0.4 0.4
				Mean		**0.425**	**0.438**	**0.413**
August 24	Fair	10	Fairly arid (after a little rain)	No. 11		0.45 0.45	0.45 0.5	0.45 0.45
				No. 12		0.4 0.45	0.45 0.45	0.45 0.45
				Mean		**0.438**	**0.463**	**0.45**

3. *Hydrangea paniculata* Sieb. (Saxifragaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value		
					8 a. m.	1 p. m.	5 p. m.
		cc.					
August 16	Cloudy-rainy	6	Arid-humid (after fine days)	No. 1	0.25	0.25	0.25
					0.25	0.25	0.25
				No. 2	0.25	0.25	0.25
					0.25	0.25	0.25
				Mean	**0.25**	**0.25**	**0.25**

4. *Diplycosia adenothrix* Nakai. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value		
					8 a. m.	1 p. m.	5 p. m.
		cc.					
August 21	Rainy	6	Humid	No. 1	0.65	0.65	0.65
					0.65	0.7	0.65
				No. 2	0.65	0.65	0.65
					0.65	0.65	0.65
				Mean	**0.65**	**0.663**	**0.65**
August 28	Rainy	5	Humid	No. 3	0.65	0.65	0.65
					0.65	0.65	0.7
				No. 4	0.65	0.65	0.7
					0.7	0.65	0.7
				Mean	**0.663**	**0.65**	**0.688**

5. *Leucothoe Grayana* Maxim. var. *Maximowicziana* Takeda. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value		
					8 a. m.	1 p. m.	5 p. m.
August 22	Cloudy, with rain at noon	cc. 11	Becoming arid (after rain)	No. 1	0.5 0.5	0.5 0.5	0.5 0.5
				No. 2	0.5 0.5	0.5 0.5	0.5 0.5
				Mean	**0.5**	**0.5**	**0.5**
August 24	Fair	19	Fairly arid (after a little rain)	No. 1	0.45 0.55	0.45 0.45	0.45 0.45
				No. 2	0.45 0.5	0.45 0.5	0.45 0.45
				Mean	**0.488**	**0.463**	**0.45**

6. *Rhododendron brachycarpum* D. Don. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value		
						8 a. m.	1 p. m.	5 p. m.
August 14	Cloudy	cc. 17	Arid after fine days)	No. 1	No. 1 No. 2	0.8 0.75	0.75 0.75	0.8 0.75
				No. 2	No. 1 No. 2	0.7 0.7	0.75 0.7	0.8 0.75
				No. 3	No. 1 No. 2	0.65 0.75	0.65 0.7	0.75 0.75
				No. 4	No. 1 No. 2	0.75 0.75	0.75 0.7	0.8 0.8
				Mean		**0.741**	**0.719**	**0.775**

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value		
						8 a. m.	1 p. m.	5 p. m.
		cc.						
August 28	Rainy	5	Humid	No. 5	No. 1	0.75	0.75	0.75
					No. 2	0.75	0.75	0.75
				No. 6	No. 1	0.75	0.75	0.8
					No. 2	0.75	0.8	0.8
				Mean		**0.75**	**0.763**	**0.775**

7. *Vaccinium hirtum* Thunb. var. *Smalli* Maxim. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value		
					8 a. m.	1 p. m.	5 p. m.
		cc.					
August 22	Cloudy, with rain at noon	11	Becoming arid (after rain)	No. 1	0.55	0.6	0.65
					0.55	0.6	0.65
				No. 2	0.55	0.55	0.6
					0.55	0.55	0.6
				Mean	**0.55**	**0.575**	**0.625**

8. *Vaccinium Vitis-Idaea* L. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value		
					8 a. m.	1 p. m.	5 p. m.
		cc.					
August 21	Rainy	6	Humid	No. 1	0.75	0.8	0.75
					0.75	0.8	0.8
				No. 2	0.75	0.75	0.75
					0.75	0.8	0.75
				Mean	**0.75**	**0.788**	**0.763**

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value		
					8 a. m.	1 p. m.	5 p. m.
		cc.					
August 28	Rainy	5	Humid	No. 3	0.8	0.75	0.8
					0.85	0.8	0.8
				No. 4	0.8	0.8	0.85
					0.8	0.85	0.85
				Mean	**0.813**	**0.8**	**0.825**

9. *Shortia soldanelloides* Makino var. *genuina* Makino. f. *typica* Makino. (Diapensiaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value		
					8 a. m.	1 p. m.	5 p. m.
		cc.					
August 19	Cloudy	11	Becoming arid (after rain)	No. 1	0.35	0.35	0.4
				No. 2	0.35	0.35	0.35
				No. 3	0.4	0.35	0.35
				No. 4	0.4	0.35	0.4
				Mean	**0.375**	**0.35**	**0.375**
August 20	Fair, with rain at 4 p. m.	20	Arid	No. 5	0.35	0.3	0.35
				No. 6	0.35	0.35	0.3
				No. 7	0.35	0.3	0.35
				No. 8	0.35	0.3	0.35
				Mean	**0.35**	**0.313**	**0.338**

A regular daily fluctuation of the osmotic value was observed in *Polygonum sachalinense*, *Rhododendron brachycarpum* and *Vaccinium hirtum* var. *Smalli*. The osmotic value increases from the morning toward the evening during the daytime. However, no distinct daily fluctuation could be recognized in the six other plants.

It is noteworthy that, in *Polygonum sachalinense*, the daily fluctuation was conspicuous on a fairly fine day immediately after rainy weather (August 19), while it was not distinct on the following days (August 20 and 24), even though they were fine.

Results in 1930.

1. *Paris tetraphylla* A. Gray. (Liliaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value 12 a. m.
		cc.			
August 24	Fair	10.8	Arid	No. 1	0.3
				No. 2	0.325
				No. 3	0.325
				No. 4	0.35
August 26	Cloudy, with rain at 3 p. m.	5.1	Humid	No. 1	0.3
				No. 2	0.325
				No. 3	0.325
				No. 4	0.35

2. *Polygonum sachalinense* Fr. Schm. (Polygonaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Shoot	Osmotic value 7 a. m.	Osmotic value 12 a. m.	Osmotic value 4 p. m.
		cc.						
July 11	Cloudy	6.1	Fairly arid	No. 1[1]	No. 1	0.325		
				No. 2	No. 1	0.375		
				No. 3		0.375		
				No. 4		0.375		
				Mean		**0.363**		
July 13	Fair	11.3	Becoming arid (after rain)	No. 1	No. 1	0.325	0.375	0.375
				No. 2	No. 1	0.375	0.425	0.475
					No. 2	0.375	0.45	0.45
				No. 5		0.35	0.4	0.45
				Mean		**0.356**	**0.413**	**0.438**
July 14	Fair	14.0	Arid	No. 1	No. 1	0.35	0.375	0.375
				No. 2	No. 1	0.375	0.45	0.4
				No. 6		0.35	0.35	0.375
				No. 7		0.325	0.35	0.4
				Mean		**0.35**	**0.381**	**0.388**

Date	Weather	Evaporation	General climatic conditions	Plant individual	Shoot	Osmotic value		
						7 a. m.	12 a. m.	4 p. m.
		cc.						
July 15	Fair	18.2	More arid	No. 1	No. 2	0.375	0.4	0.4
				No. 6		0.325	0.35	0.375
				No. 7		0.35	0.4	0.35
				No. 8		0.35	0.425	0.375
				Mean		**0.35**	**0.394**	**0.375**
July 17	Rainy	7.3	Humid (after fine days)	No. 1	No. 2			0.4
				No. 8				0.4
				No. 9				0.375
				No. 10				0.35
				Mean				**0.381**
July 18	Cloudy	8.4	Humid (after rain)	No. 1	No. 2	0.35	0.375	0.375
				No. 8		0.375	0.4	0.375
				No. 9		0.35	0.35	0.35
				No. 10		0.35	0.35	0.325
				Mean		**0.356**	**0.369**	**0.356**
July 19	Rainy	1.1	Humid	No. 2	No. 1			0.35
					No. 2			0.375
				No. 9				0.35
				No. 10				0.35
				Mean				**0.356**

3. *Ilex Sugeroki* Maxim. subsp. *brevipedunculata* Makino. (Aquifoliaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value		
						7 a. m.	12 a. m.	4 p. m.
		cc.						
August 5	Fair	19.0	Becoming arid	No. 1	No. 1		0.775	
					No. 2		0.85	
				No. 2	No. 1		0.9	
					No. 2		0.9	

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value 7 a. m.	12 a. m.	4 p. m.
		cc.						
August 7	Cloudy-rainy	5.7	Arid	No. 1	No. 1		0.8	
					No. 2		0.9	
				No. 2	No. 1		0.925	
					No. 2		0.925	
August 15	Cloudy	11.6	Humid (after rain)	No 1	No. 1		0.825	
					No. 2		0.85	
				No. 2	No. 1		0.9	
					No. 2		0.9	
August 16	Fair, with rain after 3 p. m.	11.6	Fairly humid	No. 1	No. 1	0.8	0.825	0.825
					No. 2	0.85	0.85	0.825
				No. 2	No. 1	0.9	0.85	0.85
					No. 2	0.9	0.825	0.85
				Mean		**0.863**	**0.838**	**0.838**
August 17	Fair, with rain from 12 a. m. to 2 p. m.	7.8	Humid (after rain)	No. 1	No. 1	0.825	0.8	0.8
					No. 2	0.85	0.825	0.8
				No. 2	No. 1	0.825	0.9	0.8
					No. 2	0.85	0.9	0.85
				Mean		**0.838**	**0.856**	**0.813**

4. *Diplycosia adenothrix* Nakai. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value 4 p. m.
		cc.			
August 4	Cloudy	9.0	Humid (after rain)	No. 1	0.575
				No. 2	0.525
				No. 3	0.725
				No. 4	0.85
August 6	Fair	14.6	Arid	No. 1	0.575
				No. 2	0.55
				No. 3	0.7
				No. 4	0.8

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value 4 p. m.
		cc.			
August 15	Cloudy	11.6	Humid (after rain)	No. 1	0.65
				No. 2	0.675
				No. 3	0.7
				No. 4	0.875

5. *Gaultheria Miqueliana* Takeda. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value 7 a. m.	Osmotic value 12 a. m.	Osmotic value 4 p. m.
		cc.					
August 3	Rainy	4.9	Humid	No. 1		0.725	
				No. 2		0.825	
				No. 3		0.7	
				No. 4		0.7	
August 4	Cloudy	9.0	Humid (after rain)	No. 1		0.7	
				No. 2		0.8	
				No. 3		0.7	
				No. 4		0.675	
August 6	Fair	14.6	Arid	No. 1		0.725	
				No. 2		0.8	
				No. 3		0.7	
				No. 4		0.7	
August 15	Cloudy	11.6	Humid (after rain)	No. 1		0.7	
				No. 2		0.75	
				No. 3		0.7	
				No. 4		0.675	
August 16	Fair, with rain after 3 p. m.	11.6	Fairly humid	No. 4	0.7	0.675	0.675
				No. 5	0.775	0.8	0.7
				No. 6	0.725	0.7	0.675
				No. 7	0.775	0.7	0.7
				Mean	**0.744**	**0.719**	**0.688**

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value		
					7 a. m.	12 a. m.	4 p. m.
		cc.					
August 17	Fair, with rain from 12 a. m. to 2 p. m.	7.8	Humid (after rain)	No. 1		0.75	
				No. 2		0.775	
				No. 3		0.75	
				No. 4	0.725	0.725	0.75
				No. 5	0.725	0.725	0.75
				No. 6	0.7	0.75	0.675
				No. 7	0.725	0.75	0.775
				Mean	**0.719**	**0.738**	**0.725**

6. *Leucothoe Grayana* Maxim. var. *Maximowicziana* Takeda. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value		
						7 a. m.	12 a. m.	4 p. m.
		cc.						
August 11	Fair	16.6	Fairly humid (after a little rain)	No. 1	No. 1	0.425	0.425	0.475
					No. 2	0.45	0.45	0.475
				No. 2	No. 1	0.525	0.525	0.55
					No. 2	0.5	0.525	0.525
				Mean		**0.475**	**0.481**	**0.506**
August 24	Fair	10.8	Arid	No. 3	No. 1		0.525	
					No. 2		0.525	
				No. 4	No. 1		0.5	
					No. 2		0.575	
August 26	Cloudy with rain at 3 p. m.	5.1	Humid (after rain)	No. 3	No. 1		0.5	
					No. 2		0.525	
				No. 4	No. 1		0.5	
					No. 2		0.55	

7. *Rhododendron brachycarpum* D. Don (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value 7 a. m.	12 a. m.	4 p. m.
		cc.						
July 13	Fair	11.3	Becoming arid (after rain)	No. 1	No. 1	0.525	0.55	0.575
					No. 2	0.55	0.525	0.575
				No. 2	No. 1	0.6	0.6	0.6
					No. 2	0.525		0.525
				Mean		**0.551**	**0.557**	**0.569**
July 14	Fair	14.0	Arid	No. 1	No. 1	0.575	0.6	0.55
					No. 2	0.525	0.6	0.55
				No. 2	No. 3	0.55	0.525	0.5
					No. 4	0.575	0.65	0.575
				Mean		**0.556**	**0.594**	**0.545**
July 15	Fair	18.2	More arid	No. 1	No. 3	0.6	0.625	0.6
					No 4	0.575	0.65	0.625
				No. 2	No. 3	0.5	0.5	0.5
					No. 4	0.6		0.6
				Mean		**0.569**	**0.591**	**0.583**
July 17	Rainy	7.3	Humid (after fine days)	No. 1	No. 3			0.575
					No. 4			0.6
				No. 2	No. 5			0.65
					No. 6			0.5
				Mean				**0.581**
July 18	Cloudy	8.4	Humid (after rain)	No 1	No. 3	0.65	0.65	0.6
					No. 4	0.65	0.675	0.6
				No. 2	No. 5	0.65	0.65	0.65
					No. 6	0.55	0.5	0.55
				Mean		**0.625**	**0.619**	**0.6**

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value		
						7 a. m.	12 a. m.	4 p. m.
		cc.						
July 19	Rainy	1.1	Humid	No. 1	No. 5			0.65
					No. 6			0.6
				No. 2	No. 5			0.65
					No. 6			0.5
				Mean				**0.6**

8. *Vaccinium hirtum* Thunb. var. *Smalli* Maxim. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value		
						7 a. m.	12 a. m.	4 p. m.
		cc.						
August 5	Fair	19.0	Becoming arid	No. 1	No. 1		0.45	
					No. 2		0.45	
				No. 2	No. 1		0.575	
					No. 2		0.6	
August 7	Cloudy-rainy	5.7	Arid	No 1	No. 1		0.425	
					No. 2		0.425	
				No. 2	No. 1		0.575	
					No. 2		0.55	
August 11	Fair	16.6	Fairly humid (after a little rain)	No. 3	No. 1	0.55	0.525	0.525
					No. 2	0.55	0.525	0.525
				No. 4	No. 1	0.675	0.675	0.75
					No. 2	0.675	0.675	0.65
				Mean		**0.613**	**0.600**	**0.613**
August 15	Cloudy	11.6	Humid (after rain)	No. 1	No. 1		0.5	
					No. 2		0.45	
				No. 2	No. 1		0.575	
					No. 2		0.625	

Date	Weather	Evaporation	General climatic conditions	Plant individual	Branch	Osmotic value		
						7 a. m.	12 a. m.	4 p. m.
August 17	Fair, with rain from 12 a. m. to 2 p. m.	cc. 7.8	Humid (after rain)	No. 1	No. 1		0.475	
					No. 2		0.475	
				No. 2	No. 1		0.55	
					No. 2		0.55	

9. *Vaccinium Vitis-Idaea* L. (Ericaceae)

Date	Weather	Evaporation	General climatic conditions	Plant individual	Osmotic value 4 p. m.
August 3	Rainy	cc. 4.9	Humid	No. 1	0.775
				No. 2	0.775
August 4	Cloudy	9.0	Humid (after rain)	No. 1	0.725
				No. 2	0.75
				No. 3	0.725
August 5	Fair	14.6	Arid	No. 1	0.725
				No. 2	0.675
				No. 3	0.8
August 15	Cloudy	11.6	Humid (after rain)	No. 1	0.775
				No. 2	0.675
				No. 3	0.8

From other experiments with every plant mentioned above, it was found that different leaves from about the same height on a single shoot frequently showed a difference of 0.025, a difference of even 0.05 being sometimes found. Therefore a variation of 0.025 may often be an individual variation of leaves. The osmotic value sometimes differed remarkably in different individuals of the same species of plant as shown in the above tables.

Of the nine species of plants examined, the majority, as in 1929, showed no regular daily fluctuation of the osmotic value.

Only in *Polygonum sachalinense*, the following remarkable facts could be recognized.

1. The regular daily fluctuation was distinct on a fine day immediately after rainy weather (July 13), while it was less prominent on the following fine days (July 14 and 15). And, on a humid day (July 18) it could scarcely be recognized. Similar facts were also noticed in 1929.

2. The osmotic values in the morning were almost constant without any appreciable differences between arid and humid days.

Although not very clear, the regular daily fluctuation was also found in *Leucothoe Grayana* var. *Maximowicziana.*

The writer tried in 1930, in relation to the above experiments, a few experiments in respect to the comparison of the osmotic values of the same plants in moist and dry habitats.

Polygonum sachalinense and *Ilex Sugeroki* subsp. *brevipedunculata* were tested for the effect of excessive watering on the osmotic value. On fine days a few individuals of these species growing by the Laboratory were watered plentifully and examined regarding the osmotic value before and after watering in comparison with other control individuals.

Polygonum sachalinense.

Plant individual	Osmotic value	
	Before watering (August 22, 2 p. m.)	After watering (August 23, 2 p. m.)
A	0.35 0.4	0.375 0.4
B	0.425 0.425	0.425 0.45
C (Control)	0.375 0.425	0.4 0.4
D (Control)	0.4 0.4	0.4 0.45

On the other hand, two individuals of *Ilex Sugeroki* subsp. *brevipedunculata,* standing in a stream in the garden by the Laboratory,

Ilex Sugeroki subsp. *brevipedunculata*.

Plant individual	Osmotic value	
	Before watering (August 23, 8 a. m.)	After watering (August 23, 3 p. m.)
A	0.775	0.75
	0.825	0.775
	0.85	0.85
	0.85	0.875
B (Control)	0.8	0.775
	0.85	0.775
	0.85	0.8
	0.875	0.8

showed the following values on examination also at 8 a. m. on August 23.

Plant individual	Branch	Osmotic value
C	No. 1	0.8
		0.875
	No. 2	0.875
		0.875
D	No. 1	0.825
		0.875
	No. 2	0.875
		0.875

In the scope of the above experiments, practically no distinct effect of watering could be noticed in those two plants. Moreover *Ilex Sugeroki* subsp. *brevipedunculata*, standing on an extremely moist soil, showed no remarkably lower values.

The following two species of plants were examined in both moist and dry habitats, on days of almost similar climatic conditions.

Geum pentapetalum Makino. (Rosaceae)

Plant individual	Osmotic value	
	Growing on rocks on the summit of Ôdake (August 13, 4 p. m.)	Cultivated in the stream by the Laboratory (August 23, 4 p. m.)
No. 1	0.7	0.6
	0.725	0.65
No. 2	0.725	0.6
	0.75	0.675

Pentastemon frutescens Lamb. (Scrophulariaceae)

Plant individual	Osmotic value			
	Growing on rocks on the summit of Ôdake (August 13, 11 a. m.)	Cultivated by the Laboratory:		
		on ordinary ground		under a fountain (August 22, 11 a. m.)
		(August 22, 11 a. m.)	(August 25, 11 a. m.)	
No. 1	0.45	0.325	0.375	0.325
No. 2	0.45	0.35	0.375	0.35
No. 3	0.45	0.375	0.375	0.35
No. 4	0.475	0.425	0.375	0.425

It is clearly shown that both the plants showed much higher osmotic values on rocks on the summit of Ôdake than in more or less moist habitats by the Laboratory.

DISCUSSION AND CONCLUSIONS

As to the nature of the osmotic value of various plants, BLAGOWESTSCHENSKI (1, 2) pointed out, on the basis of experiments of his own and of other authors, that each species of plant has a definite normal osmotic value, which is peculiar to it as a constitutional characteristic, and that this value can fluctuate to some extent, being affected by external conditions, especially the moisture of the soil, as well as by internal causes, and that the magnitude of fluctuation is

different in different species of plants — some plants show always a constant value in various conditions, whereas some others easily change the value according to the change of conditions.

WALTER (7) confirmed these facts and, moreover, stated that distinct daily fluctuation of the osmotic value did not take place in those plants which show a narrow range of fluctuation of the value.

The results obtained by the writer's experiments are well consistent with these statements.

The occurrence of the regular daily fluctuation of the osmotic value was proved, at any rate, in a few species of plants — *Polygonum sachalinense*, *Leucothoe Grayana* var. *Maximowicziana*, *Rhododendron brachycarpum* and *Vaccinium hirtum* var. *Smalli* ; although the majority of plants examined, which may belong to the group of plants with a narrow range of fluctuation of the osmotic value, showed no distinct fluctuation.

The fact noticed in *Polygonum sachalinense*, that the osmotic value was almost constant in the morning through a series of days, indicates that the osmotic value substantially repeated a regular fluctuation every day at any rate, and, on the other hand, that the climatic changes day by day appeared to have no remarkable effect upon the magnitude of the osmotic value. The latter fact was recognized also in other plants than *Polygonum sachalinense*.

It is worth noting that in *Polygonum sachalinense* the fluctuation was most conspicuous on fine days immediately after rainy weather. It may be due to a rapid change of the moisture in the soil.

In our previous paper, we pointed out that the osmotic value of certain plants varies to some extent according to the environment, particularly to the water factors. This was proved in the present investigation in *Geum pentapetalum* and *Pentastemon frutescens*, which showed much higher osmotic values on rocks on the summit of Ôdake than in more or less moist places by the Laboratory. In this respect the writer intends to conduct more experiments in the future.

SUMMARY

1. The author investigated several species of phanerogams growing by the Mt. Hakkôda Botanical Laboratory in respect to the

occurrence of regular daily fluctuation of the osmotic value and the effect of climatic conditions upon it.

2. A few species of plants showed regular daily fluctuation of the osmotic value, while the majority did not.

3. It was found in *Polygonum sachalinense* that the fluctuation was most conspicuous on fine days immediately after rainy weather.

4. The climatic changes day by day appeared to have no remarkable effect upon the magnitude of the osmotic value.

The writer wishes to express his cordial thanks to Professor Dr. Y. YOSHII, under whose direction this investigation was made in the Mt. Hakkôda Botanical Laboratory.

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Botanische Studien subalpiner Moore auf vulkanischer Asche.[1]

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(Mit Tafeln VIII–XI und 29 Textfiguren)

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Der Kegelberg Ôdake mit einer Kratereinsenkung am Gipfel erreicht eine Höhe von 1,580 m ü. M. und steht in der Mitte des Hakkôda-Massivs. Die Vulkane zeigen jetzt keine lebhafte Tätigkeit, sind jedoch im Solfatarenzustande. Es gibt nämlich auf einem Abhang einen alten Krater, der einen heissen breiigen Schlammsprudel hat; ferner trifft man in seiner Umgebung, wie an anderen Stellen das Vulkangebiets viele heisse Quellen. Obwohl wir von dem letzten Ausbruche keine genaue Kenntnis besitzen, so unterliegt es doch keinem Zweifel, dass noch in geologisch neuerer Zeit viele Ausbrüche stattgefunden haben, wovon später die Rede sein wird.

Der Berg Ôdake hat besonders schöne Abhänge auf seiner Süd- und Westseite. Auf einem westlichen Abhang kann man zwei ausgedehnte flache Terrassen sehen, die in Abstufungen mit einer Entfernung von etwa 100 m Höhe übereinander liegen. Die obere Terrasse, 1,150 m ü. M., umfasst annähernd 25 ha, während die untere kleiner ist. Beide ebene Gelände senken sich sanft nach Westen, und ihr Böschungswinkel beträgt nur 1.7–3.5 Grad.

Die ökologischen Aussenbedingungen beider Gelände sind im grossen und ganzen gleich, und daher trifft man bei beiden fast dieselbe Physiognomie der Grasformation an. Das Grasgelände zeichnet sich dadurch aus, dass eine grosse Anzahl kleiner Teiche mit gewölbtem Rand darauf zerstreut sind. Dieser Teichkomplex erinnert lebhaft an ein Reisfeld in der Ebene, und man sagt, dass der Name des Berges Hakkôda (Hakkô = acht Berge, Da(Ta) = Reisfeld) hiervon abgeleitet sei.

[1] Contributions from the Mt. Hakkôda Botanical Laboratory. No. 9.

In dieser Abhandlung wollen wir die Entwicklung des Teichgebiets sowie die Vegetation im Teichgebiet näher erforschen. Bevor wir uns mit dem morphologischen Bau und der Entwicklung des Teichgebiets und seiner Vegetation im einzelnen beschäftigen, wenden wir uns zunächt der Grasformation zu.

I. ÜBERSICHT ÜBER DIE VEGETATION AUF DEM MOORBODEN.

Die Vegetation auf beiden Terrassen ist im grossen und ganzen einfach und zeigt eine geschlossene Grasformation, die überwiegend aus grasartigen Pflanzen und Kräutern mit spärlich eingestreuten Zwergsträuchern und Bäumen besteht. Physiognomisch werden sie daher durch grasartige Pflanzen gekennzeichnet und als Graswiese bezeichnet. Genetisch betrachtet, wie später noch genauer auseinandergesetzt werden wird, entsteht diese Vegetation auf Torfboden, der über undurchlässiger, vulkanischer Asche liegt. Bei der Schneeschmelze im Frühjahr und bei grossen Niederschlägen im Herbst werden die Pflanzen auf dem Torfboden zeitweise überschwemmt, aber in der übrigen Zeit wachsen sie auf durchnässtem Torfboden, der durch Quell- oder Sickerwasser dauernd nass ist und nur im Sommer teilweise austrocknet, während er an niedrigen Stellen und um die Teiche herum sogar in der trockenen Zeit nass bleibt. Die reichliche Wasserzufuhr im Boden, zusammen mit dem kalten Bergklima[1], begünstigt die Torfbildung und auch die Entwicklung von Moorpflanzen.

Die Oberfläche des Torfbodens erhöht sich jedoch durch den langsam, aber stetig sich bildenden Moortorf allmählich, wodurch die Ansiedlung vieler Gräser und Kräuter begünstigt wird, die aber nach und nach von den die Austrocknung der Bodenoberfläche ertragenden Pflanzen abgelöst werden. Und zwar herrscht *Molinia japonica*[2] vor. RÜBEL (1930, S. 272)[3] hat unter anderem darauf hingewiesen, dass ***Molinietum*** im allgemeinen eine Austrocknung der Bodenoberfläche im Sommer erträgt und diese Austrocknung auch für das *Molinietum*-Moorgebiet charakteristisch ist. An einigen Stellen erhebt sich ferner der Moortorf

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1) Über das Bergklima vergl. YOSHII, Y. und JIMBO, T., Science Reports Tôhoku Imp. Univ. 4th Ser. (Biol.) Vol. 6, p. 261. 1931.

2) Vergl. hierzu ein Synonym *Moliniopsis japonica*; HAYATA, B., Tokyo Bot. Mag. Vol. 39, p. 255. 1925.

3) RÜBEL, E., Pflanzengesellschaften der Erde. 1930.

ausgeprägt über das Grundwasserniveau hinaus, und die Oberfläche ist deutlich ausgetrocknet, wodurch die Durchlüftungsverhältnisse verbessert sind, sodass sich viele Zweigsträucher und Bäume ansiedeln konnten. Sie gehen allmählich in zwischenmoorartige Gebüsche über. In diesem Buschwald herrscht *Pinus pumila* vor, gemischt mit *Cornus canadensis* und *Abies Mariesii.* Diese Gebüsche wachsen hier und da über den Torfboden verstreut und bilden einen besonders üppigen Buschwald auf dem Abhang. Ferner verändert sich die Grasformation mit der grösseren Tiefe des Grundwassers in der Nähe der Bäche, und es kommen Übergänge zu zwischenmoorartigen Büschen vor. Um einen Teich herum bleibt aber der Boden durch das Sickerwasser stets durchnässt, sogar im trocknen Sommer, und infolgedessen trifft man hier eine spezifische Pflanzengesellschaft an, von der später noch die Rede sein wird. Anderseits geht das Grasmoor öfters ins eigentliche Hochmoor über, indem *Sphagna* nach und nach zahlreicher werden, obwohl sich keine Erhöhung des Hochmoors erkennen lässt. Dass hier verhältnismässig wenig *Sphagna* vorkommen, ist darauf zurückzuführen, dass das Torfmoos für seine Entwicklung nicht des offenen Wassers, sondern nur der feuchten Luft bedarf. Hervorgehoben sei hier, dass der Torfboden starkem Sonnenlicht ausgesetzt ist und die Vegetation wenigstens in den Sommermonaten in ziemlich ausgetrockneter Atmosphäre wachsen muss.

II. ENTWICKLUNG OLIGOTROPHER MOORE.

Zum Studium der Entwicklungsgeschichte dieses Moors muss man zunächst zahlreiche Bohrungen ausführen, was zur Zeit noch nicht geschehen ist. Wir können daher auf dieses Problem jetzt nicht genauer eingehen, sondern dafür nur eine durch einen Teich ausgeführte Grabung benutzen. Das Profilbild des Moorbodens kann vorläufig eine Übersicht über die Schichtenfolge geben, die wahrscheinlich in Lagerung und Material nicht stark von anderen Orten abweichen. wird. Nach dieser Aufgrabung können wir soviel sicher sagen, dass sich die Moore immer auf vulkanischer Asche entwickelt haben.

Wie sich aus nebenstehendem Profilbild erkennen lässt, liegen wenigstens drei Aschen und drei Torfschichten übereinander. Die oberste Torfschicht, die sich im durchnässten Boden gebildet hat, ist

etwa 20 cm dick, und darunter liegt die oberste Aschenschicht, die 16 cm Dicke hat und für die Moorvegetation eine grosse Rolle spielt, weil die Nässe des Feldes zum grössten Teil in ihrer Undurchlässigkeit begründet ist. Unter dieser Aschenschicht liegt die zweite sehr dünne Torfschicht, die nur 1 cm dick ist, und unter dieser wieder eine dicke, weissgraue Aschenschicht von 15 cm Dicke, die ganz unberührt von Vegetation blieb. Die daran sich anschliessende dritte Torfschicht von 35 cm Dicke ist ganz ähnlich wie die oberste und besteht hauptsächlich aus Resten von Wurzeln und Stengeln von Gräsern und Seggen zusammen mit Sphagna, jedoch ist keine deutliche Ablagerung von Schlammschichten von Wasserpflanzen zu erkennen. Wir können danach vermuten, dass die früheren Moorvegetationen annähernd ähnliche Physiognomie zeigten, wie die heutige, m. a. W. sie bestanden auch hauptsächlich aus Graswiese, und niemals herrschten eigentliche Hochmoor- oder typische Flachmoorpflanzen vor.

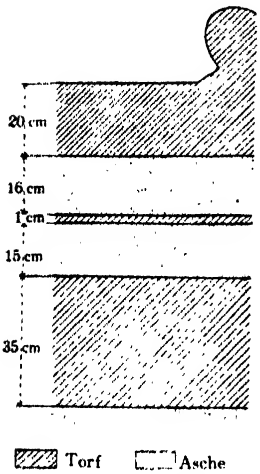

Fig. 1. Profilbild des Moorbodens.

Das Profil bestätigt häufige Ausbrüche des Vulkans, die nach einem kurzen oder langen Zeitraum einander gefolgt sind. Eine grosse Menge vulkanischer Aschen und Sande, vielleicht auch öfters von Bimstein, wurde bei dem Ausbruche auf den Abhängen des Vulkans abgelagert, und diese sammelten sich besonders massig auf den in Frage kommenden Terrassen. Die ausgeworfenen Massen verwitterten allmählich, und endlich entstand da ein schlammiger Aschenboden, der so hart zusammengepresst wurde, dass er das Wasser kaum durchliess. Sowohl durch starke Niederschläge wie durch Schneeschmelze wurde zunächst ein grosser, seichter See auf dem flachen Aschenboden gebildet. Durch starke Austrocknung im Sommer wird er vorübergehend teilweise zur Pfütze, doch bleibt das Wasser an jeder niedrigen Stelle als ein seichter Teich zurück. Diese auf nährstoffarmem Boden gebildeten Teiche begünstigen nur die Ansiedlung oligotropher Wasserpflanzen. Mit der Stagnierung des nährstoffarmen Sickerwassers in den Senkungen wurde der Boden anderseits versumpft und setzte die

Torfbildung, durch das Bergklima unterstützt, ganz überwiegend aus den unter Wasser befindlichen Wurzeln und Stengeln der Pflanzen ein, ganz wie sie hier noch heute erfolgt. Das Moor entsteht in dieser Weise aus Verlandung eines nährstoffarmen Sees, oder aus direkter Versumpfung des nährstoffarmen Bodens. Der Verlandungsvorgang muss aber anders erfolgen als der in einem nährstoffreichen See, d. h. bei der Flachmoorbildung mit Gyttjaablagerung auf dem Seegrund. Die Torfbildung setzte sich so lange fort, bis ein Ausbruch des Vulkans sie ganz vernichtet hatte, dann begann von neuem die gleiche Reihenfolge der Torfbildung, wie das Profilbild es zeigt. Die Frage, ob die gegenwärtigen Teiche die letzten Reste dieser ursprünglichen Gewässer seien, kann man vorläufig noch nicht entscheiden. Man kann jedoch soviel sagen, dass die meisten Teiche auf dem Torf nur um solche Stellen herum liegen, wo Quellwasser austritt.

Wie erwähnt, setzt die Moorbildung mit Stagnierung des Quellwassers in der flachen Senke auf dem kaum durchlässigen Aschenboden ein. Das Quellwasser spielt also für die Entstehung dieser Moore eine grosse Rolle, und man kann sie daher genetisch in die Kategorie der Quellmoore einreihen. Unter Quellmooren, die dem Austritt von Quellen oder Sickerwasser ihre Entstehung verdanken, versteht man aber im allgemeinen solche, die auf nährstoffreichem Gelände entstehen und folglich mit eutrophen Pflanzen bewachsen sind, was aber bei uns nicht der Fall ist. Der geologische Aufbau des Quellmoors und die Quellmoorbildung ist von Geologen gelegentlich behandelt worden, jedoch besteht nur eine spärliche Literatur über die Formationsbiologie der Quellmoore. Unter anderem hat STEFFEN (1922)[1] eine eingehende Untersuchung über die Quellmoore des preussischen Landrückens ausgeführt. Nach ihm erfolgt zunächst deutliche Ablagerung von Kalktuff durch Kalkausscheidung des kalkhaltigen Grundwassers auf dem Untergrund, dann entstehen die Quellmoore oder Gehängemoore auf dieser nährstoffreichen Grundlage, wobei die Moore natürlich die Eigenschaft der Flachmoore besitzen. In unserem Fall ist es aber ganz anders; das Grundwasser auf dem Aschenboden ist nährstoffarm und stark sauer; folglich siedeln sich auf dem Moor oligotrophe Pflanzen an, wie das beim Hochmoore vorkommt, aber es ist keine Wölbung von

[1] STEFFEN, H., Botan. Arch. Bd. 1, S. 261. 1922.

Sphagna zu erkennen. Hier sei bemerkt, dass SENDTNER (1854)[1] schon darauf hingewiesen hat, dass der Charakter der Quell- oder Sickermoore je nach der chemischen Beschaffenheit des durchnässten Bodens bald Hoch-, bald Wiesenmoor ist. In neuerer Zeit hat KOPPE (1926)[2] mit Recht eine Einteilung der Moore nach dem Nährstoffgehalt des Moorbodens und nicht nach ihren morphologischen Eigenschaften vorgeschlagen. Die Moore werden gewöhnlich nach der Vegetation und der durch sie bedingten Form in Flach-, Zwischen- und Hochmoore eingeteilt. Es gibt nach KOPPE ein Moor, dem zahlreiche morphologische Merkmale des echten Hochmoores fehlen, das jedoch völlig oligotrophe Vegetation (oder unter etwas günstigeren Verhältnissen eine mesotrophe) trägt. Solche Moore liegen aber nicht auf früher gebildeten Flachmooren, sondern direkt auf nährstoffarmen Sandböden. Er bezeichnete solche Moore als primäre oligotrophe Moore (od. primäre Zwischenmoore) und unterschied sie von gewöhnlichen Hochmooren, die sich durch weiteres Wachsen von mesotrophen oder eutrophen Mooren aus entwickelten. Diese Einteilung nach dem Nährstoffgehalt der Moors scheint den Vorzug zu haben, für mancherlei Moore in verschiedenen Klimaten gültig zu sein.

Wir möchten nun unsere Moore auf nährstoffarmem, vulkanischem Aschenboden in die oligotrophen Moore einreihen, obwohl ihre Vegetation sowie ihre Form wenige Merkmale des typischen Hoch- oder Zwischenmoors besitzt.

III. ENTWICKLUNG EINES TEICHS AUF MOORBODEN.

Wie aus Tabelle I am Schluss zu erkennen ist, liegen die meisten Teiche, die mit ausgeprägtem Rand versehen sind, an solchen Stellen, wo der horizontale oder schwach geneigte Boden plötzlich seine Neigung verändert. Das stimmt mit der Voraussetzung gut überein, dass das unmittelbar über die Aschenschicht fliessende Wasser an dieser Stelle austreten muss. Das Wasser kommt sogar im trocknen Sommer heraus, und die Bodendurchnässung hält um diesen Quellpunkt herum das ganze Jahr hindurch an. Infolgedessen tritt dort üppige Vegetation auf. Besonders siedeln sich anspruchslose Pflanzen, wie Gräser,

1) SENDTNER, zitiert in STEFFEN, S. 276.

2) KOPPE, F., Ber. d. bot. Gesell. Bd. 44, S. 584. 1926.

Seggen und Torfmoos, an. Unter dem Einfluss des Quellwassers geht die Torfbildung durch die Wurzelüberreste und Stengelteile der üppig wachsenden Pflanzen weiter. Die Ablagerung des Torfs nimmt allmählich am Rand des Quellpunkts mehr und mehr zu. Das Quellwasser durchnässt weiter die Unterlage des vom Torf gebildeten Randes und begünstigt damit das Emporwachsen der Gräser und auch die Ansiedlung anderer Pflanzen. Mit dem Emporsteigen des Randes füllt das Quellwasser den Teich aus, und je höher das Wasserniveau steigt, desto mehr wölbt sich der untere Rand, indem seine Unterlage stets vom Teichwasser durchnässt ist und ihn zu weiterem Wachstum von Pflanzen veranlasst. Während sich die untere Randseite mit dem Ansteigen des Wasserniveaus immer mehr erhebt, zeigt die obere keine ausgeprägte Erhebung, und die Bodenfläche dient als oberer Rand des Teichs, weil auf dieser Seite die Pflanzen nur wenig mit Teichwasser versorgt werden. Dadurch ist das topographische Aussehen des Teichs ganz ausgezeichnet, wie sich aus einer Photographie (Fig. 10 auf Tafel X) leicht erkennen lässt. Dieser Entwicklungsvorgang eines Teichs ist aus nebenstehender Abbildung 2 leicht zu verstehen, die der Übersicht halber eine schematische Darstellung gibt. Der Rand erreicht selten über 40 cm Höhe, ist jedoch mit hoch gewachsenen Gräsern üppig bewachsen und zeigt auffälliges Aussehen auf flachem Grasland. Die einzelne Pflanze, die sich in bezug auf ihren Wasseranspruch verschieden verhält, siedelt sich auf einer bestimmten Stelle des Randes an. Der starkem Sonnenlicht ausgesetzte äussere oder untere Rand ist mit die Austrocknung gut ertragenden Pflanzen bewachsen; dagegen

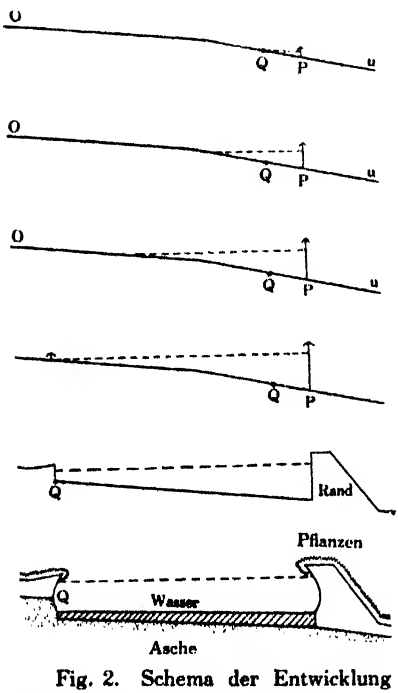

Fig. 2. Schema der Entwicklung eines Teichs. Q....Quellpunkt
P....Pflanze

begünstigt der innere oder obere Rand die Ansiedlung Nässe liebender Pflanzen. Das Vorkommen eigentlicher Pflanzengesellschaften um den Teich herum beruht daher völlig auf der verschiedenen Durchtränkung mit Quellwasser.

IV. MORPHOLOGISCHER BAU DES TEICHS.

Bevor wir auf den Bau des einzelnen Teichs näher eingehen, seien die wichtigsten Ergebnisse der Messung jedes Teichs kurz zusammengefasst. Zunächst wird ein Beispiel der Messung des Teichs in einer

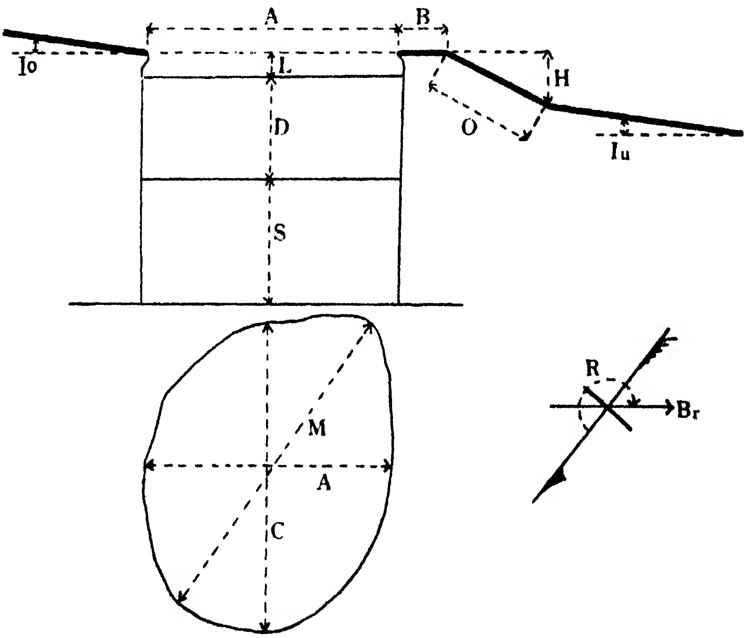

Fig. 3. Skizze eines Teichs. Oberes Bild; Querschnitt des Teichs, darunter ein Bild von oben.

A Breite in der Böschungsrichtung
C Breite, senkrecht zur Böschung
M die grösste Breite
B Breite des Randes
O schiefe Fläche
H Höhe des Randes
L Tiefe vom Mund bis zur Wasseroberfläche
D Wassertiefe
S Schlammtiefe
Iu Böschungswinkel auf der unteren Seite
Io Böschungswinkel auf der oberen Seite
R Winkelgrad
Br Böschungsrichtung

schematischen Abbildung 3 gegeben. Wie sich aus der am Schluss der Abhandlung stehenden Tabelle I erkennen lässt, neigen sich alle Teiche auf beiden Terrassen sanft gegen Westen, obwohl der Böschungswinkel wie auch die Böschungsrichtung nach Exposition und Lage des Teichs geringe Abweichungen zeigen.

1. Die Form eines Teichs ist im Grunde eine Ellipse, deren längere Achse senkrecht zur Böschungsrichtung steht (Fig. 4). Man trifft aber viele unregelmässige Formen, besonders im Teichkomplex am Fuss der Böschung an.

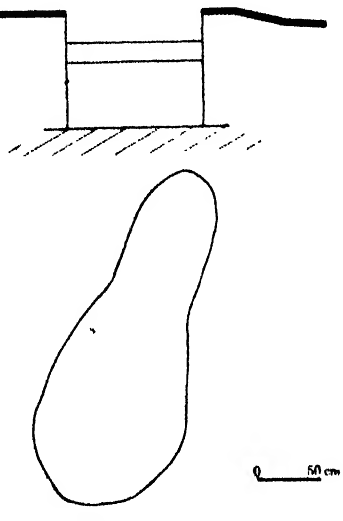

Fig. 4. Teiche IV.

2. Die Grösse ist auch sehr verschieden; der grösste Teich Marunuma umfasst etwa 230 qm, die anderen aber bilden meistens nur kleine Tümpel, und es gibt sogar so kleine, dass man sie kaum erkennen kann.

3. Die Bedingungen für die Entwicklung des Teichrandes sind hier mannigfaltig, und infolgedessen treten die mit ausgeprägtem Rand versehenen Teiche über das Teichgebiet zerstreut auf. Von den 78 untersuchten Teichen besitzen 40 einen deutlich gewölbten Rand. Die Verbreitung solcher Teiche ist in diesem Grasmoor je nach der Lage des Teichgebiets verschieden, wie aus folgender Zusammenfassung hervorgeht:

	Sämtliche Teiche	Mit Rand versehene Teiche
I. Teichgebiet[1]	10	10
II. Teichgebiet	24	1
III. Teichgebiet	31	22
IV. Teichgebiet	13	7

Daraus ergibt sich, dass die Teiche der untersten Stufe (Teichgebiet I) alle einen deutlichen Rand besitzen, während sich im Teichgebiet

1) Über die Einteilung des Teichgebiets siehe S. 317.

II nur bei einem einzigen Teich unter den 24 ein Rand entwickelt.

4. Die Höhe der Ränder weicht sehr voneinander ab, aber die durchschnittliche beträgt 23 cm, während die höchste auf 59 cm und die niedrigste auf 5 cm geschätzt wird. Die Breite des Randufers ist je nach dem Entwicklungsgrad wie der Lage verschieden, aber im grossen und ganzen schwankt sie zwischen 20–40 cm, durchschnittlich beträgt sie 37 cm.

5. Der Böschungswinkel der schiefen Fläche des Randes ist auch verschieden, je nach der Entwicklung des Randes, in der Tabelle mit H/O bezeichnet, d. h. mit dem Sinus des Winkels. Den grössten schätzen wir auf 0.83 (etwa 56 Grad) und den kleinsten auf 0.14 (etwa 8 Grad).

6. Im trocknen Sommer kann das Wasserniveau etwas sinken, jedoch bemerkt man in den meisten Teichen nur geringe Abnahme. Das Verhältnis ist ganz auf die Versorgung mit Quellwasser zurückzuführen, worauf unten noch weiter eingegangen werden wird. Das Wasserniveau steht deshalb in den meisten Teichen, die mit einem Rand versehen sind, höher als die Fläche des Grundbodens (H—L), indem das höchste 37 cm höher steht.

7. Die Tiefe des Wassers äussert sich verschieden je nach der Struktur des Teichs, aber im allgemeinen sind die Teiche sehr seicht und überschreiten nur selten 60 cm Tiefe. Das gilt natürlich nicht für den grössten Teich, Marunuma.

8. Die Dicke der Schlammschicht zusammen mit der obersten Torfschicht ist, soweit sie durch Stichprobe mit einem Stock festgestellt wurde, sehr verschieden, aber fast immer weniger als 1 m Tiefe und beträgt meistens nur ungefähr 30–40 cm.

9. Das Wichtigste ist in der Tat die Verschiedenheit des Böschungswinkels des oberen und unteren Grundbodens eines Teichs. Wie oben schon erwähnt, tritt das über die kaum durchlässige Aschenschicht fliessende Grundwasser an solchen Stellen aus, wo der Winkel plötzlich verändert ist. Nach den Messungen aller Fälle ist der Böschungswinkel des unteren Bodens (Iu) in 64% aller gemessenen Teiche weit grösser als der des oberen (Io).[1]

[1] Siehe Tabelle I am Schluss dieser Abhandlung.

V. EINTEILUNG DES TEICHGEBIETS.

Auf den ersten Blick scheinen diese auf den beiden Terrassen liegenden Teiche ganz unregelmässig verteilt (Fig. 5), und doch können

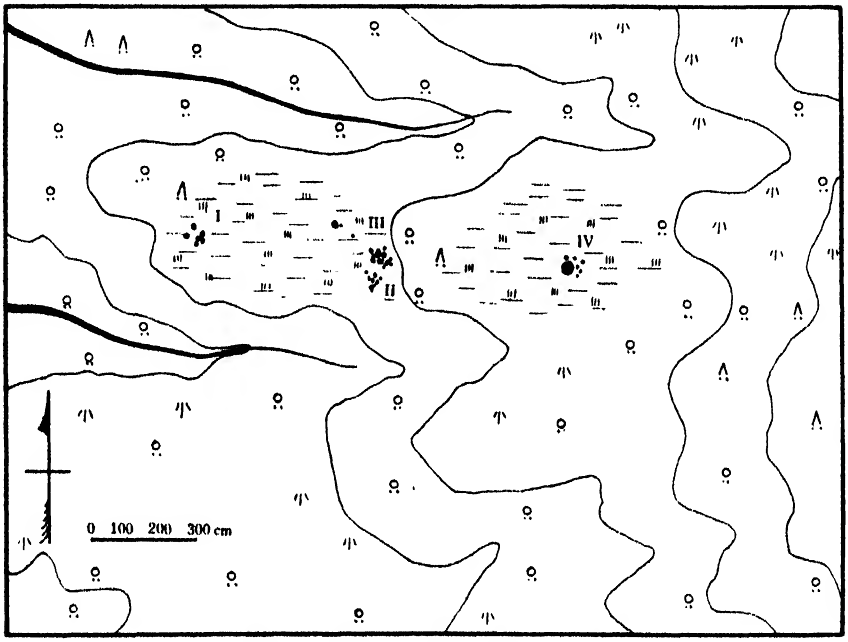

Fig. 5. Kärtchen des Teichgebiets.

wir sie nach Lage und Entwicklungsgeschichte in vier Gruppen einteilen. Während die eine auf der oberen Terrasse sich befindet, liegen die anderen drei auf der unteren, und zwei davon ganz nahe nebeneinander in Gruppen am Fuss der steilen Böschung zwischen den Terrassen (Fig. 5 und 6 auf Tafel IX).

Die untere Terrasse lässt sich weiter in zwei Stufen unterscheiden, die aber keinen grossen Unterschied aufweisen. Die obere Stufe dehnt sich am Fuss der steilen Böschung aus und erstreckt sich weit hinunter, mit geringer Neigung auf der unteren Stufe. Die Physiognomie der beiden Stufen der unteren Terrasse ist im Grunde ähnlich wie die der oberen. Gemäss der Verschiedenheit der Topographie zeigen sie doch ein abweichendes Aussehen.

1. In der unteren Stufe finden wir 10 Teiche, die über viele

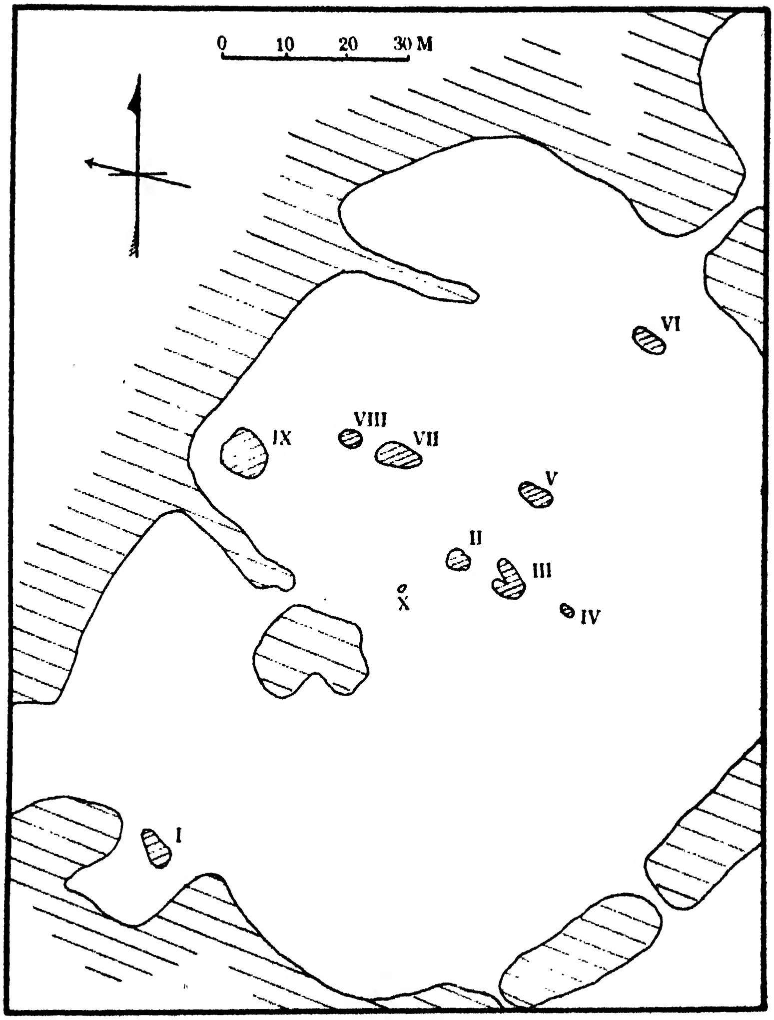

Fig. 6. Teichgebiet auf der unteren Terrasse (Die erste Gruppe).

Stellen zerstreut sind. Diese Teiche zeichnen sich dadurch aus, dass jeder mit erheblich gewölbtem Rande versehen ist. Die meisten Teiche besitzen elliptische Form, deren lange Achse in der Böschungsrichtung liegt. Fig. 7 zeigt einen typischen Teich (T. VI). Er hat eine schöne Birnenform, sein Rand erreicht 59 cm Höhe, der höchste unter den untersuchten. Er ist mit Quellwasser ausgefüllt, und zwar steht die

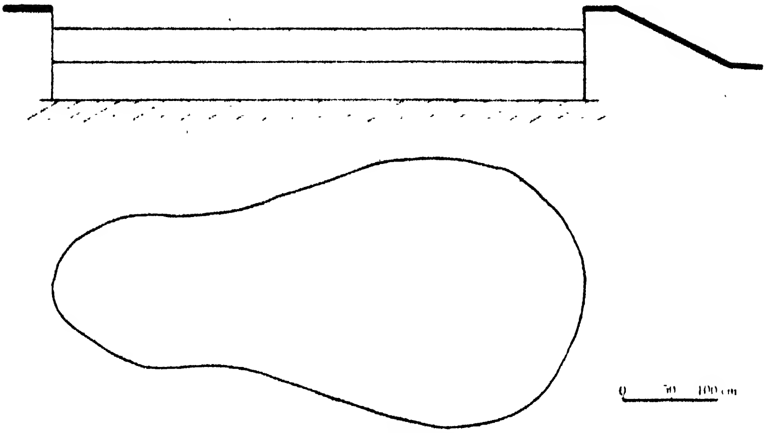

Fig. 7. Teich VI.

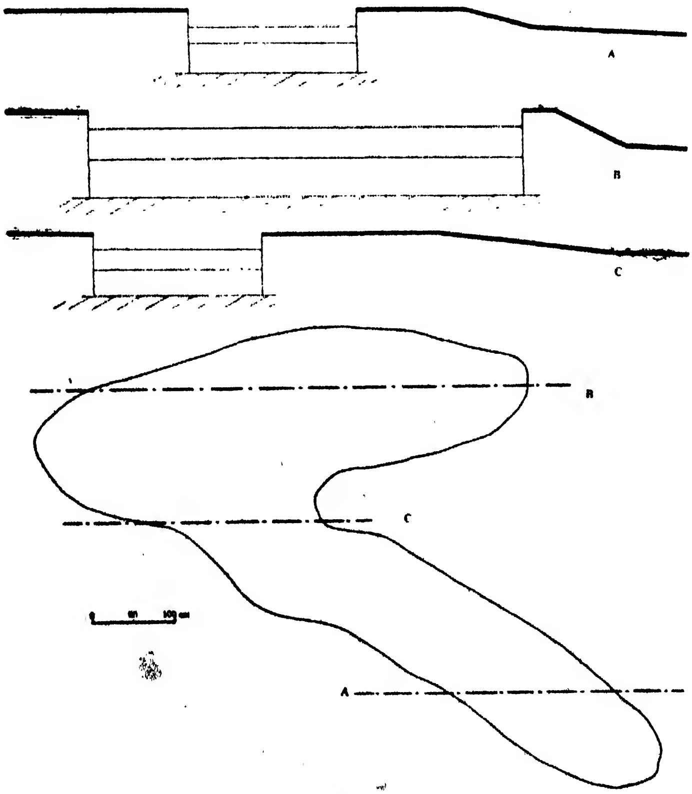

Fig. 8. Teich III.

Wasseroberfläche 37 cm über dem unteren Grundboden. Anderseits hat T. III eine unregelmässige Form, wie wenn zwei elliptische Teiche verbunden wären. Das ist aber nicht der Fall. Wie sich aus nebenstehenden drei Profilen erkennen lässt, erreicht das Randufer seine grösste Weite in der Mitte, wo die Teichkuppel am schmalsten ist. Aus dieser Tatsache glauben wir zu erkennen, dass ein grosser Teich in der Mitte des Torfmoors zu Land geworden ist. Er bietet daher

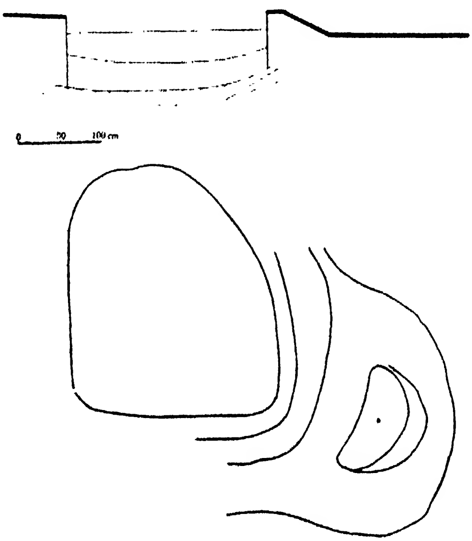

Fig. 9. Teich II.

ein gutes Beispiel der Entwicklung eines Teichs dar. T. II zeichnet sich auch durch einen deutlichen Rand aus, jedoch ist er nur spärlich mit Wasser ausgefüllt. Wie aus Fig. 9 ersichtlich, liegt daneben ein kleiner, ausgetrockneter Teich, und ferner liegen auf einer diese beiden verbindenden Linie T. III, IV an der oberen Seite und T. IX an der unteren in einer Reihe (cff. Fig. 6). Der unterste Teich ist ganz ausgetrocknet und auf seinem Boden haben sich viele Landpflanzen angesiedelt, denen sich *Molinia japonica*, *Eriophorum gracile* und *Geum pentapetalum* angeschlossen haben, wovon später wieder die Rede sein wird (Fig. 10). Dass die auf der unteren Stufe liegenden Teiche mit wenig Wasser versorgt sind, ist darauf zurückzuführen, dass das Quellwasser je nach dem Zufluss allmählich weniger wird. Disse Reihe

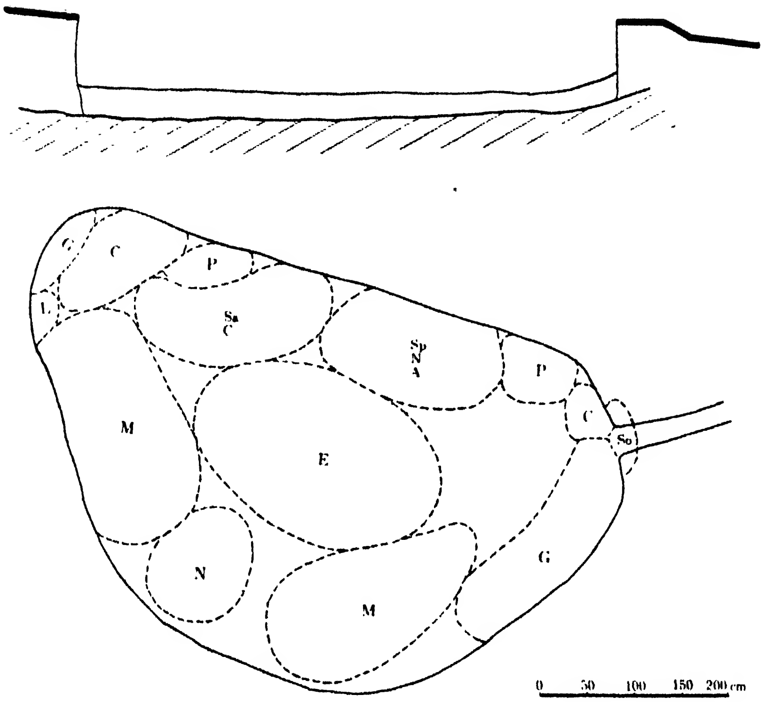

Fig. 10. Teich IX.

A *Aletris foliata*
C *Carex stellulata*
E *Eriophorum gracile*
G *Geum pentapetalum*
L *Lysichiton camtschatense*
M *Molinia japonica*
N *Narthecium asiaticum*
P *Polytrichum sp.*
Sa *Salix Reinii*
Sp *Sphagnum sp.*
So *Sorbus Aucuparia*

von Teichen auf einer Böschung zeigt den Rest eines früheren Bachs, was unten bei einem anderen Falle noch näher auseinandergesetzt werden wird.

Im Gegensatz zu den zerstreuten Teichen der ersten Gruppe bildet sich am Fuss des Abhangs ein Teichkomplex (Fig. 11), der sich dadurch auszeichnet, dass zahlreiche Teiche durch einen schmalen Rain voneinander getrennt sind, ganz wie bei den Reisfeldern. In der Volkssprache dieser Gegend trägt dieser Teichkomplex daher den Namen Kaminota („Kami "=„Gott", „no" Genitiv-Partikel, „Ta "=„Reisfeld"). In der Mitte des Teichkomplexes liegt ein ausgedehntes

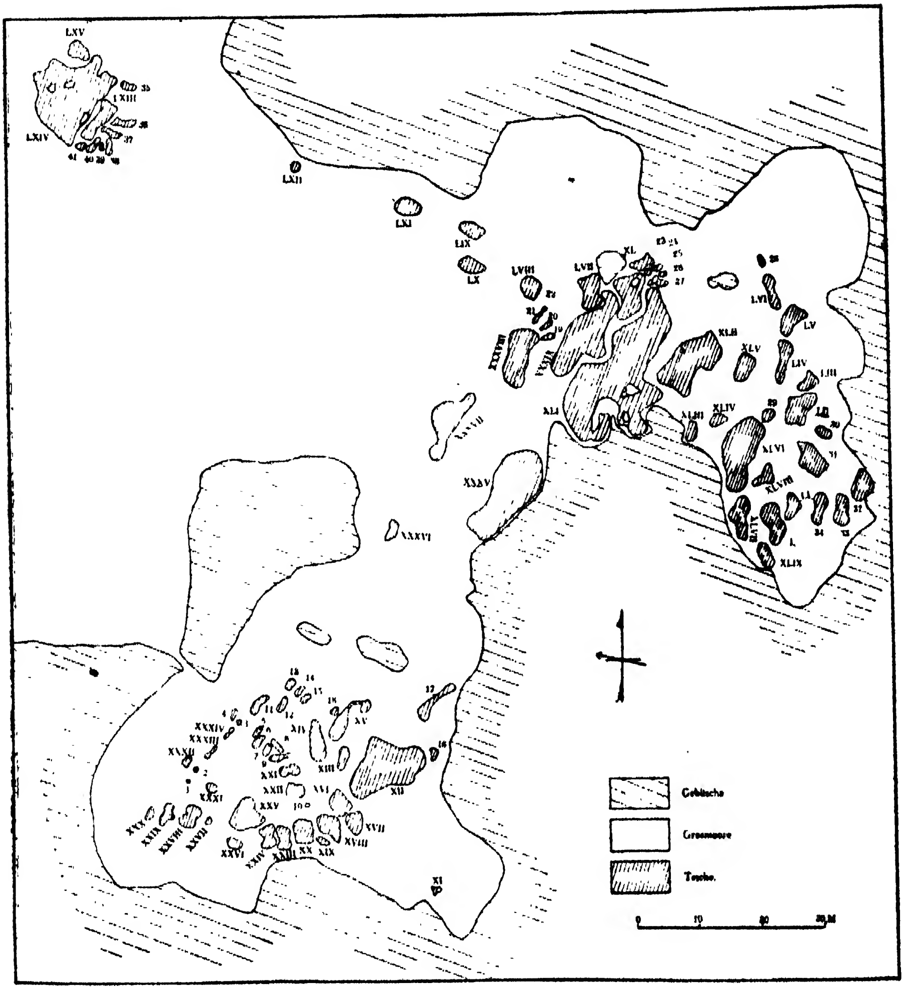

Fig. 11. Teichkomplex am Fuss des Abhangs: oben Gruppe III, unten Gruppe II.

Gebüschland, durch das er in zwei Teile getrennt wird. Die beiden Teichkomplexe sind nicht nur in ihrer morphologischen Form, sondern auch in ihrer Vegetation deutlich voneinander verschieden, infolge der Verschiedenheit ihrer ökologischen Bedingungen. Während der eine (Gruppe III) aus etwas grösseren Teichen besteht und sich über ausgedehntes Gelände verbreitet, besteht der andere (Gruppe II) aus kleineren, die auf einem verhältnismässig schmalen Gebiet zusammen

liegen. Obwohl beide in gleicher Weise mit Quellwasser versorgt werden, kommt der erste auf einem stärker durchnässten Boden vor, während der letzte, durch den daneben sich befindenden steilen Abhang beeinflusst, auf ziemlich ausgetrocknetem Boden liegt.

2. Die zweite Gruppe besteht aus 25 Teichen, die nahe zusammen liegen. Sie wird nach dem Wasserversorgungsgrad wieder in zwei getrennt; die unmittelbar am Fuss des Abhangs liegende und die davon entfernt nach aussen hinliegende. Während die erste aus den mit Wasser erfüllten, grösseren Teichen besteht, gehören die kleineren, annähernd ausgetrockneten Teiche zu der letzten Gruppe, wie aus Fig. 11 leicht zu erkennen ist. Dieser Unterschied ist darauf zurückzuführen, dass das Quellwasser aus der oberen Terrasse am Fuss des Abhangs austritt und genügend viel Wasser den inneren Teichen liefert, jedoch für die Wasserversorgung der äusseren Teiche fast versagt. Die Verkleinerung der Teiche der äusseren Gruppe ist aber nicht nur auf die Austrocknung des Bodens, sondern auch auf das Überwuchern der Moorvegetation zurückzuführen, genau wie das beim wenig durchnässten Bestand der Fall ist.

Dieser Teichkomplex erscheint aber zum Teil als nasser Bestand, und an der Torfbildung beteiligte Pflanzen wie *Narthecium asiaticum* wachsen hier besonders üppig. Bemerkt sei, dass hier keine deutliche Wölbung des Randes auftritt. Das kommt sicher davon her, dass der Boden im ganzen flach ist. Wie oben erwähnt, erfolgt die Aufwölbung des Randes nur dann, wenn das Quellwasser im geneigten und wenig durchnässten Boden an einem Punkte austritt und rings darum solche Pflanzen wachsen können, wie Gräser und Seggen, die sich an der Torfbildung beteiligen. Das gilt hier nicht, wo Nässe liebende Pflanzen auf einem flachen Boden um einen Teichkomplex herum in grosser Menge gedeihen und an anderen Stellen sogar ein ausgetrockneter Bestand vorkommt.

Es ist auch charakteristisch für dieses Gebiet, dass bei einigen Teichen (z. B. T. X V) teilweise Verlandung stattfand und der schlammige Unterboden zum Vorschein kommt und dort schon einige Landpflanzen sich angesiedelt haben.

In der jetzt von den kleinen Teichen aus sich ausdehnenden Senke muss in früherer Zeit ein grosser Teich oder See gewesen sein. Er besass aber verhältnismässig sehr flachen Unterboden und sumpfige

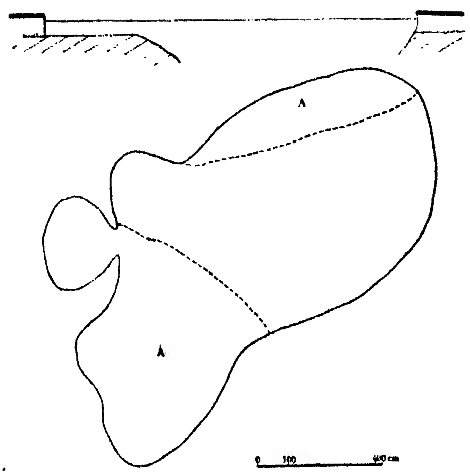

Fig. 12. Teich XII.
A········ ausgetrockneter Teil

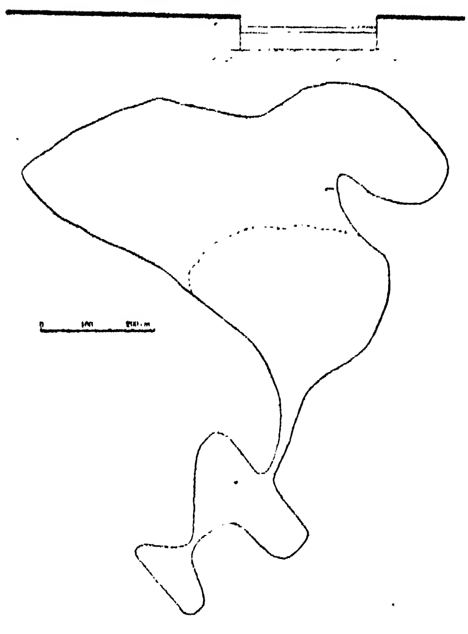

Fig. 13. Teich XV.

Ufer, so dass viele sumpfige Pflanzen darin gedeihen konnten. Das Überwuchern und die Ablagerung am Ufer sowohl wie im Innern nahmen zu, bis der See allmählich mit Torfmoor bedeckt war. In dieser Weise ist der See verlandet und zum jetzigen Moorland geworden, indem um die Quellpunkte herum das freie Wasser als kleine Teiche erhalten blieb.

Im Folgenden sollen einige ausgeprägte Teiche beschrieben werden.

T. XII ist der grösste in dieser Gruppe, dessen Unterlage noch unklar bleibt, dessen grösster Teil aber seicht ist und in dem sich eine grosse Menge von Schlamm abgelagert hat. T. XV hat eine sehr unregelmässige Form, die durch teilweise Verlandung verursacht ist, ein Teil ist bereits ganz ausgetrocknet. T. XXI und XXIV (in Fig. 16) zeigen den Übergang zur Verlandung, indem die untere Seite deutliche Aufwölbung des Unterbodens zeigt.

Eine deutliche Form lässt sich bei T. XXVIII erkennen, da durch Torfablage-

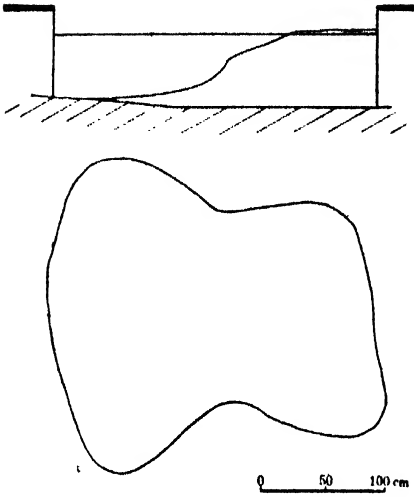

Fig. 14. Teich XXI.

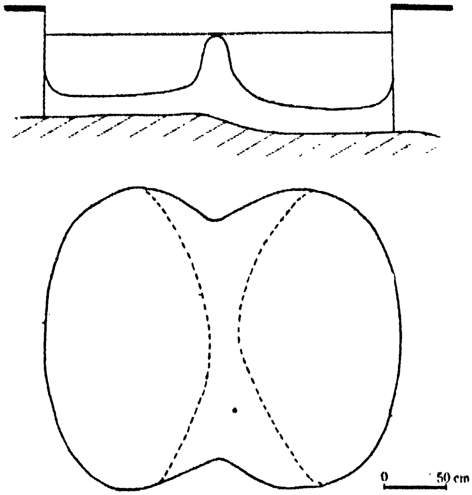

Fig. 15. Teich XXVIII.

rung das Ufer auf jeder Seite in zwei Teile getrennt ist, ganz ähnlich wie bei dem von OSVALD (1923)[1] in einem Hochmoor in Schweden beschriebenen Teichtrichter (S. 361, Fig. 92).

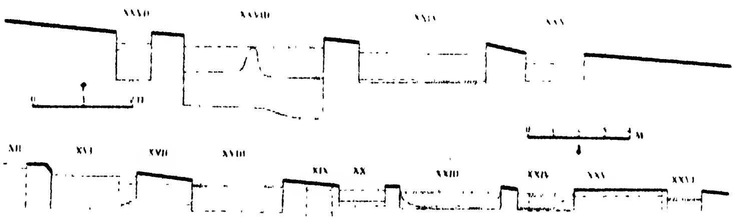

Fig. 16. Zwei Profile durch einige Teiche.

Zum Schluss bringen wir in Fig. 16 zwei Profile durch die Teiche auf geneigtem Boden. Man kann daraus eine Übersicht über die Reihe der Teiche gewinnen, die in diesem Teichkomplex vorkommen.

3. Die dritte Gruppe (Fig. 11 auf S. 322) ist die schönste und bemerkenswerteste in der Graswiese. Sie besteht aus 35 Teichen und etwa 23 undeutlichen Teichresten. Die meisten Teiche liegen am Fusse der Steilböschung, während einige sich in der Böschungsrichtung

[1] OSVALD, H., Die Vegetation des Hochmoores Komosse. Upsala, 1923.

nach Westen ausdehnen.

Wir können sie nach ihrer Lage in zwei Gruppen, die obere und die untere, einteilen. Während die oben am Fuss des Abhangs zerstreut liegende Gruppe aus 27 Teichen (T. XXXVI — T. LVII) und 16 ausgetrockneten (T. 19 — T. 34) besteht, gehören zu der unten dicht beisammen liegenden nur 3 Teiche (T. LXIII — T. LXV) und 7 ausgetrocknete (T. 35 — T. 41). Man trifft noch 5 Teiche zwischen beiden an, von denen später noch die Rede sein wird.

Die meisten Teiche in diesem Gebiet zeichnen sich durch einen ausgeprägt gewölbten Rand aus. In diesem Punkte haben sie Ähnlichkeit mit dem ersten Teichkomplex.

Zunächst werden wir von dem morphologischen Bau einiger Teiche

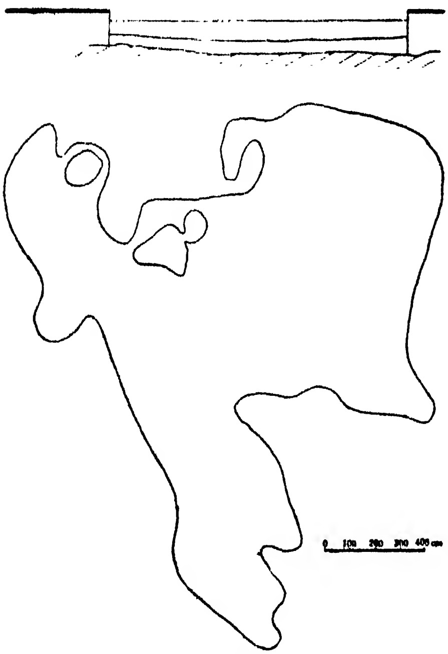

Fig. 17. Teich XLI.

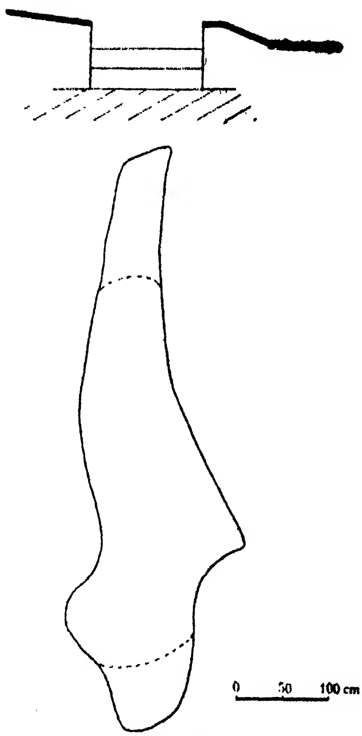

Fig. 18. Teich LIV.

sprechen. T. XLI liegt in der Mitte der oben liegenden Gruppe und ist der grösste, seine Tiefe ist aber seicht und beträgt, vom oberen

Moorrand gemessen, ungefähr 50 cm, ihm folgt eine Ansiedlung vieler Sumpfpflanzen. Die Ursache seiner unregelmässigen Form ist in seiner Verlandung zu suchen. T. LIV ist ein Beispiel für Teiche mit ausgeprägtem Rand. (Fig. 2 auf der Tafel VIII). Er zeigt auch die Übergangsform zur Verlandung, indem beide Enden schon ausgetrocknet sind. Die anderen Teiche haben im grossen und ganzen Ähnlichkeit mit den oben erwähnten, weshalb wir uns nicht weiter damit beschäftigen.

Die oben bei Gruppe II von der Verlandung eines Sees ausgesprochene Vermutung gilt auch hier. Es ist ein grosser Teich auf dem Aschenboden der Terrasse am Fuss des Abhangs gewessen, und zwar hat er zusammen mit dem Teichkomplex II einen noch grösseren See gebildet, der allmählich in Torfmoor übergegangen ist, während jetzt noch seine Teichreste auf dem Torfboden erhalten geblieben sind.

Alle Teiche verdanken ihre Entstehung diesem früheren See in einer Senke. Die sechs Teiche T. LVII — LXII liegen auf einem geneigten Grund in einer Reihe, indem sie durch das unter dem Torf abfliessende Quellwasser verbunden sind, das auf dem undurchlässigen Aschenboden recht langsam fliesst. Sie sind sicher Fragmente einer alten Bachrinne, die aus dem oberen grossen See gespeist wurde.

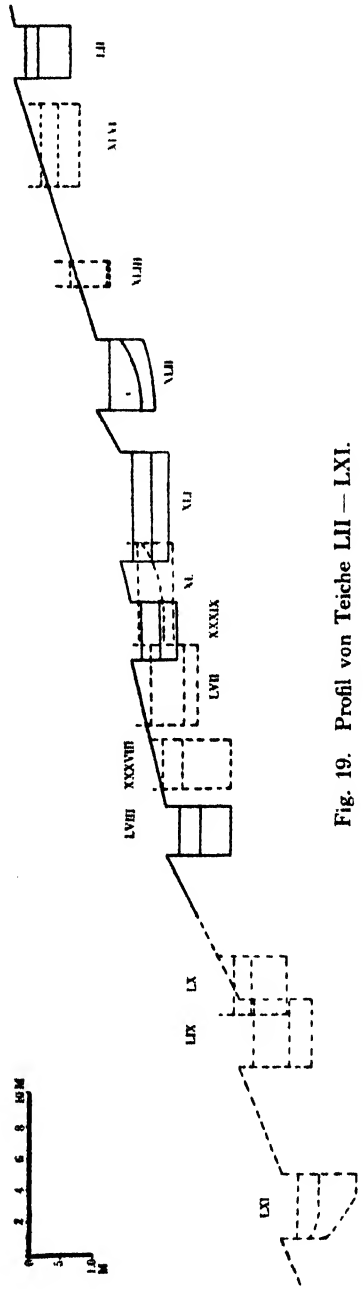

Fig. 19. Profil von Teiche LII — LXI.

Diese Reihe von Teichen ist in der Tat die schönste in der Graswiese und zeigt den Verlandungsvorgang einer Bachrinne, die aus der oberen Teichgruppe (einem früheren See) her kam und in die untere Teichgruppe (einen anderen früheren Teich) mündete. Ein Profil durch die zentralen Teile dieser Reihe von Teichen lässt sich in der Profiltafel erkennen. Obwohl die Torfschichtunterlage nicht immer mit der Oberfläche des Grundlandes übereinstimmt, so zeigt doch der Wasserspiegel eines jeden Teichs der Lage nach immer allmählichen Abfall, wie sich aus der Abbildung 19 leicht erkennen lässt.

Zum Schlusse sei bemerkt, dass die auf dem geneigten Gelände voneinander entfernt liegenden Teiche alle mit ausgeprägt erhöhtem Rand versehen sind. Sie haben fast die gleiche Rundform, indem

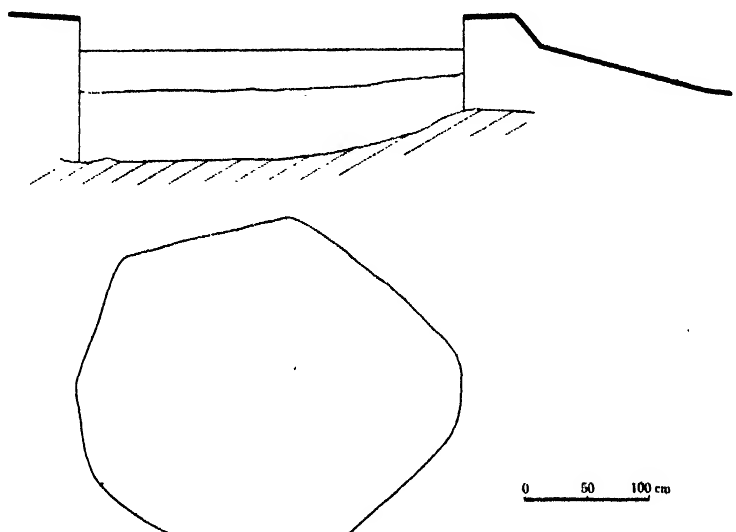

Fig. 20. Teich LXI.

deutliche Ablagerung des Untergrunds stets auf der unteren Seite vorkommt, wofür der Teich LXI in Fig. 20 ein Beispiel bietet.

4. Die vierte, die in der Mitte der oberen Terrasse liegt, besteht aus mehr als 20 kleinen Teichen. Diese breiten sich gruppenweise oberhalb des grössten Teiches Marunuma aus. Er ist der grösste auf diesem Grasmoor, und sein Wasserspiegel ist etwa 230 qm gross, dessen Niveau aber etwa 1 m niedriger als die Grundoberfläche des Bodens

ist. Dadurch sind die ihn umgebenden Teiche stark ausgetrocknet, obwohl die grössere Bodennässe an anderen Stellen der Terrasse

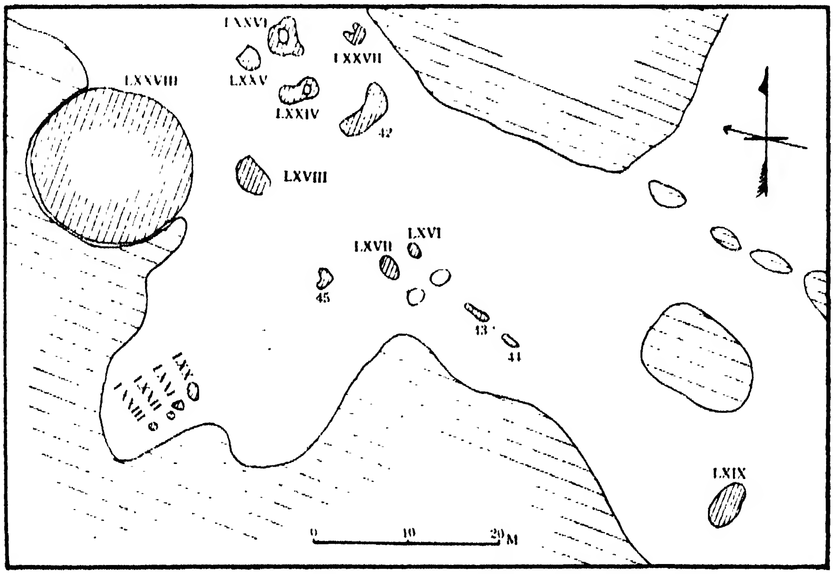

Fig. 21. Teichgebiet auf der oberen Terrasse (Die vierte Gruppe).

erhalten ist. In der Tat trifft man in diesem Teichgebiet stellenweise einige Reste ausgetrockneter Teiche, die in Fig. 21 mit römischen Ziffern bezeichnet sind. Fig. 22 (T. LXXIV) skizziert einen annähernd

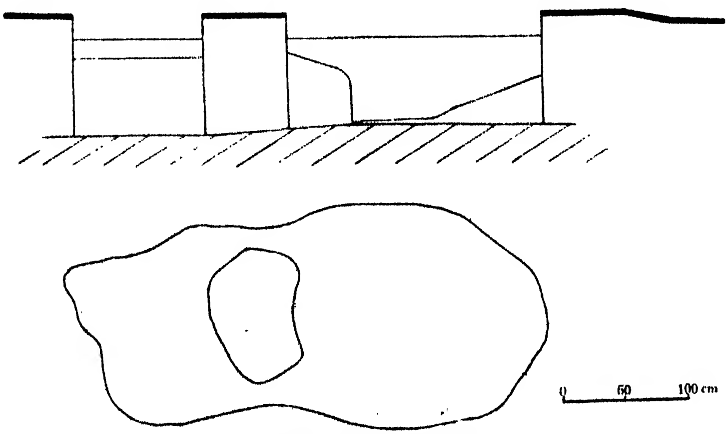

Fig. 22. Teich LXXIV.

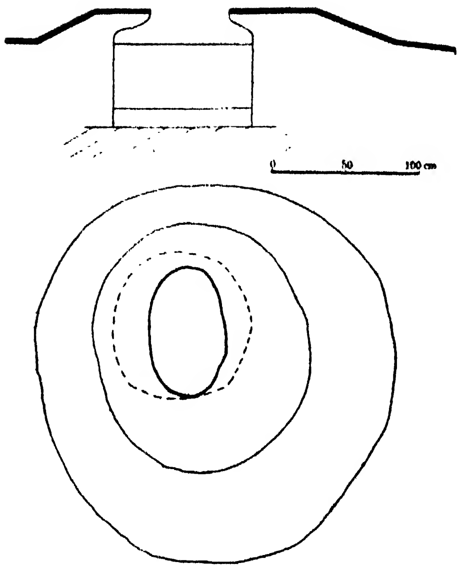

Fig. 23. Teich LXVII.

ausgetrockneten Teich, dessen unterer Boden schon an einer Stelle zum Vorschein kommt und nur wenig Wasser in der Unterlage zeigt. Die meisten Teiche zeichnen sich ferner durch den Bechertypus aus, dessen Mund durch die Entwicklung des Oberflächen-Torfmoors sich verkleinert und damit eine spezifische Form aufweist, die im Profilbild von Fig. 23 veranschaulicht ist (T. LXVII). Sie erinnert an einen Trichter, der von OSVALD beim Komosse-Moore beschrieben wurde.

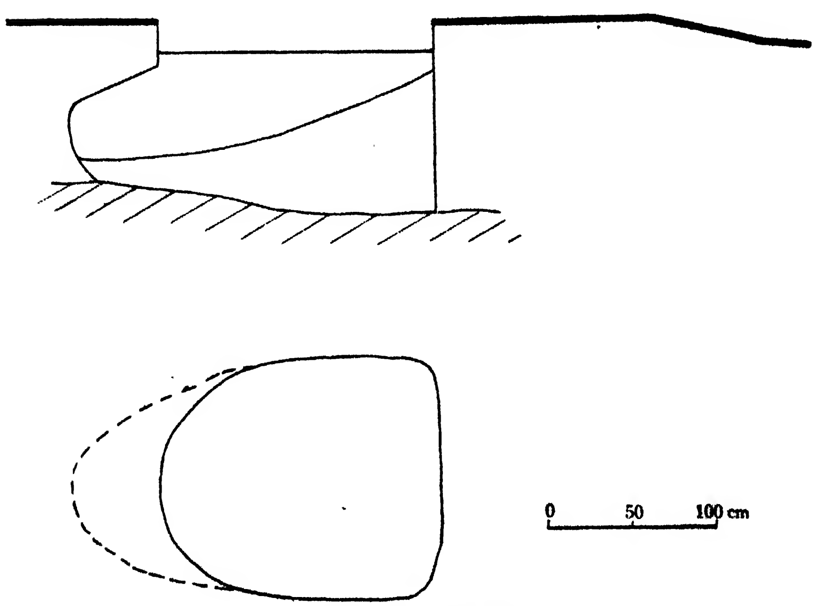

Fig. 24. Teich LXXV.

Eine noch verwickeltere Form lässt sich in Fig. 24 (T. LXXV) erkennen, bei der sich ihr oberer Rand entwickelt. Der für das Profilbild der Bodenschichten ausgegrabene Teich wird auch hier gefunden.

Zum Schlusse möchten wir noch eine Reihe von Trichtern beschreiben. Vier Teiche (LXX — LXXIII) liegen auf einem geneigten Moorboden (Fig. 25). Der Böschungswinkel zwischen den beiden nebeneinander liegenden Teichen ist nicht gleich; je tiefer nach unten der Teich liegt, desto grösser wird der Winkel; er beträgt 7°, 10° und 13°. Danach ist es sehr wahrscheinlich, dass der Rest einer Bachrinne jetzt doch durch das unten fliessende Wasser entsprechend der Neigung stets in Verbindung damit bleibt. Wie oben erwähnt, sind die Teiche jetzt im Begriff, auszutrocknen, während sie in früherer Zeit hier zusammen einen grossen See gebildet haben werden.

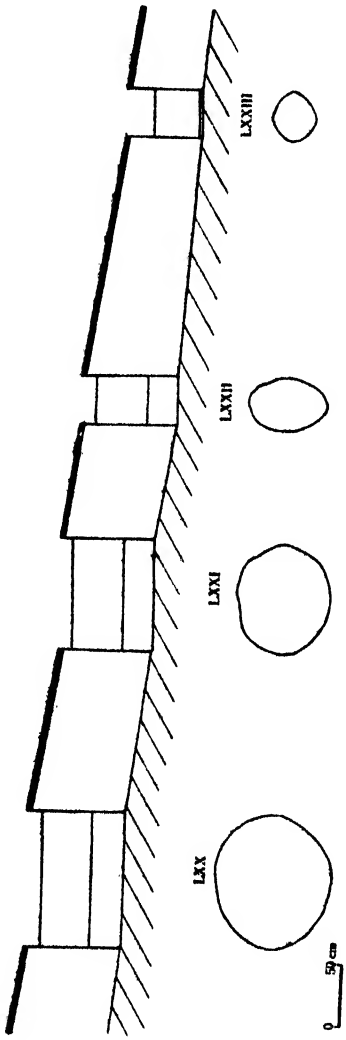

Fig. 25. Profil von Teiche LXX — LXXIII.

VI. VEGETATION DES TEICHBESTANDS.

Zur Analyse der Vegetation ist die allgemein bekannte Methode der Standortsaufnahme verwendet worden. Alle Aufnahmen wurden über den Einzelbestand um jeden Teich herum gemacht; dabei wurden die oberen[1] und die unteren Pflanzengesellschaften getrennt untersucht, weil jede einzelne in den

[1] Genau genommen, umfasst die obere Gesellschaft, besonders an einem mit Rand versehenen Teich, auch die der beiden Seiten des Teiches.

meisten Fällen eine verschiedene Vegetationseinheit besass. Obwohl die Grösse der Aufnahmefläche jedes einheitlichen Bestandes je nach der Grösse, der Form und dem Bau des Teiches sehr verschieden ist, so sind zum Vergleich der Einzelbestände diese Einheiten doch sehr zweckmässig.

Bei den Bestandaufnahmen begnügten wir uns mit der floristischen Zusammensetzung jedes Teichbestandes und dem Stetigkeitsgrad der einzelnen Art in jedem Teichgebiet und berücksichtigten den Bedekkungsgrad nicht weiter. Um eine wesentliche Bestandskonstitution zu schaffen, haben wir Stetigkeitszahlen der Arten, als S in Tabelle II bezeichnet, in Prozenten angegeben.

Durch diese Aufnahmen jedes Bestandes erhält man einen guten Einblick in die Konstitution der Pflanzengesellschaft an jedem Teiche sowie in die Verbreitung jeder Art.

Im folgenden wird die Vegetationskonstitution des Teichbestandes je nach dem Teichgebiet nacheinander behandelt werden.

1. Alle Teiche im ersten Teichgebiet zeichnen sich durch ihren aufgewölbten Rand aus. Man kann daher einen deutlichen Unterschied in den Bestandsbedingungen zwischen der oberen und der unteren Seite erwarten. In diesem Teichgebiet wurden im ganzen 21 Arten gefunden, von denen 5 stete Arten sind, nämlich *Molinia japonica*, *Eriophorum gracile*, *Narthecium asiaticum*, *Geum pentapetalum* und *Oxycoccus palustris* var. *intermedium*. Die letztgenannte Art trifft man in den anderen Gebieten selten oder gar nicht an. Während diese 21 Arten bei irgend einem Teichbestand auf der unteren Seite gefunden wurden, trifft man auf der oberen im ganzen nur 13 Arten. *Molinia japonica* dominiert und tritt auf beiden Seiten jedes Teiches auf. Während *Drosera rotundifolia* fast immer nur auf der oberen Seite vorkommt, tritt *Shortia soldanelloides* in den meisten Fällen auf der unteren auf. Besonders beachte man, dass *Calamagrostis sachalinensis*, *Aletris foliata* und *Hosta japonica* var. *angustifolia* nur auf der unteren Seite gefunden werden. *Fauria Crista-galli*, *Lobelia sessilifolia* und *Oxycoccus palustris* var. *intermedium* gehören auch zu dieser Gruppe. Das Vorkommen dieser Nässe liebenden Pflanzen auf der unteren Seite scheint mit der ausreichenden Bodenfeuchtigkeit des erheblich entwickelten Randes im Zusammenhang zu stehen. Solche Pflanzen, wie *Heloniopsis breviscapa*, *Ledum palustre* var. *nipponicum*,

Menziesia pentandra und *Diplycosia adenothrix* gehören zu der Gruppe von zufälligen Arten.

2. Im zweiten Teichgebiet finden wir nur 14 Arten, obwohl 21 Teiche dazu gehören. Mit der einen Ausnahme von *Drosera rotundifolia*, die fast immer nur auf der oberen Seite auftritt, verbreiten sich alle anderen Pflanzen in gleicher Weise über beide Seiten des Teiches. Hier sei bemerkt, dass die Teiche in diesem Gebiet ganz nahe beieinander liegen und keinen deutlichen Rand erkennen lassen. Es ist daher öfters schwer zu sagen, zu welcher Seite eines Teichs ein Rand gehört, weil ein und derselbe Rand auch zugleich zu dem nächsten Teiche gehört. *Molinia japonica* und *Eriophorum gracile* dominieren hier, ausserdem sind *Narthecium asiaticum* und *Geum pentapetalum* auch als stete Arten anzusehen. Bemerkt sei noch, dass *Oxycoccus palustris* var. *intermedium* als zufällige Art auftritt, die sich im ersten Teichgebiet als stete Art erweist. Wir können hier keine charakteristische Art bemerken, doch wächst *Scheuchzelia palustris* hier besonders reichlich. Diese Segge tritt nur im Teichgebiete am Fuss des Abhanges auf und fehlt in den anderen. Wahrscheinlich ist sie ein Relikt der Moorpflanzen, die früher in diesem Gebiet üppig

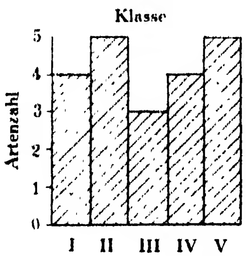

Fig. 26. Konstitutionsdiagramm des I. Teichgebiets.

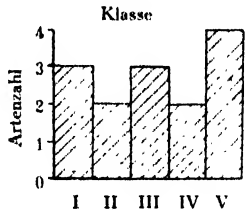

Fig. 27. Konstitutionsdiagamm des II. Teichgebiets.

wuchsen. Wie aus nebenstehendem Konstitutionsdiagramm leicht zu ersehen, verbreiten sich viele Arten homogenetisch, und damit zeigt sich eine einheitliche Assoziation in diesem Gebiet.

3. In dem dritten Gebiet befinden sich 26 Teiche, und im ganzen kommen 31 Arten vor, von denen auch 5 als stete Arten dominieren. Obwohl diese dominierenden Arten ganz dieselben wie in der ersten Gruppe sind, so äussert sich hier doch eine ziemlich verschiedene Artzusammensetzung. Während sich das Vorkommen von *Drosera*

rotundifolia auch hier in den meisten Fällen auf die obere Seite beschränkt, tritt *Geum pentapetalum* im grossen und ganzen nur auf der unteren auf. *Sphagnum sp.* wächst sehr üppig und hat eine hohe Stetigkeit. Man trifft auch hier *Oxycoccus palustris* var. *intermedium* und *Shortia soldanelloides* hauptsächlich auf der unteren Seite an. *Potamogeton polygonifolius* ist eine der zufälligen Arten, wächst jedoch üppig und schafft der Gesellschaft ein spezifisches Aussehen.

Wie nach der Topographie erwartet, begegnet man in diesem Teichgebiet vielen verschiedenen Beständen, die ihrerseits auch wieder verschiedene Artzusammensetzung besitzen. Wie aus Tabelle II ersichtlich, verbreiten sich viele Arten zerstreut. Das Verhältnis lässt sich leicht aus dem Diagramm erkennen: Man findet in der Stetenklasse (80–100) 5 Arten und in den nächst niedrigen mittelhohen Klassen je 1, während in der niedrigen Klasse 7 und in der niedrigsten (0–20) 17 Arten enthalten sind. Es zeigt eine uneinheitliche Pflanzengesellschaft. Das beruht darauf, dass das Feuchtigkeitsverhältnis des Bodens je nach dem Entwicklungsgrad an vielen Flecken voneinander abweicht, wie aus der oben erwähnten Morphologie dieses Teichkomplexes verständlich wird. Die Pflanzengesellschaft ist wenigstens aus zwei verschiedenen Beständen zusammengesetzt: Der eine besitzt relativ wenige Elemente, die hauptsächlich auf sumpfigem Boden auftreten, und der andere umfasst viele Arten, die auf ausgetrocknetem Gelände vorkommen. Während der erste auf die Relikte in der Entwicklung des Teichgebiets hinweist, zeigt der letzte die Wirkung der Austrocknung des Landes auf die Artzusammensetzung. Der Artenreichtum dieses Gebiets

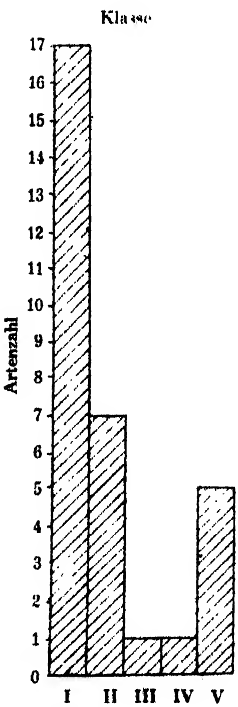

Fig. 28. Konstitutionsdiagramm des III. Teichgebiets.

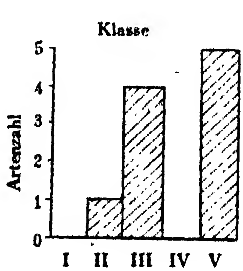

Fig. 29. Konstitutionsdiagramm des IV. Teichgebiets.

ist daher ohne weiteres auf die Mannigfaltigkeit seiner ökologischen Bedingungen zurückzuführen, worauf schon JACCARD (1928)[1] hingewiesen hat (S. 200). Höchstwahrscheinlich zeigt dieses Gebiet das letzte Stadium der Verlandung. Folgende Pflanzen befinden sich nur in diesem Gebiet, obwohl sie auch da nur in geringer Menge auftreten: *Phragmites communis, Ligularia sibirica, Veratrum stamineum, Lycopodium clavatum, L. obscurum, Menziesia pentandra, Rhododendron brachycarpum, Pinus pumila, Trientalis europaea, Carex sp.* von denen die erst genannten 5 Arten zu den hygrophilen Pflanzen gehören und sich als Relikte des sumpfartigen Gebiets erweisen, während die letzt genannten 5 Arten xerophile Pflanzen sind und gemäss der Austrocknung des Landes sich ansiedelten.

4. Von den auf der oberen Terrasse liegenden Teichen können wir nur 4 zum Vergleich heranziehen, weil die übrigen infolge der Austrocknung beider Seiten eines Teichs keine deutliche Abweichung in der Vegetation aufweisen.

Infolge der geringen Anzahl der Teiche können wir nur 10 Arten finden, von denen 4 Arten, *Molinia japonica, Eriophorum gracile, Drosera rotundifolia* und *Geum pentapetalum*, stets auf allen Teichbeständen auftreten. Das Gebiet ist sehr einheitlich und hat keine charakteristische Art, es zeichnet sich aber dadurch aus, dass *Narthecium asiaticum* in geringer Menge vorkommt, während *Drosera rotundifolia* überall üppig wächst. Es fehlen solche Arten wie *Calamagrostis sachalinensis, Oxycoccus palustris* var. *intermedium* und *Aletris foliata*, die sich in den anderen Teichgebieten immer befinden, wenn auch öfters nur in geringer Menge. Wie erwähnt, beginnt infolge des niedrigen Wasserniveaus des grössten Teichs Marunuma das umgebende Gebiet auszutrocknen. Leider ist die Anzahl der erforschten Teichbestände zu gering, um die Bestandaufnahme weiter zu erörtern.

Im Anschluss an die Teichbestände sprechen wir über die Pflanzengesellschaften der Teiche. In den meisten Teichen, d. h. in 56 Teichen unter den 69 erforschten, trifft man viele Wasserpflanzen an, die in dem seichten Unterboden wurzeln und durch das freie Wasser hindurch gewachsen sind. Im ganzen lassen sich 12 Arten erkennen.

Wie aus Tabelle III ersichtlich, kommt *Menyanthes trifoliata* in allen

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[1] JACCARD, P., ABDERHALDEN Handb. d. biol. Arbeitsmeth. Abt. 11, T. 5, S. 165. 1928.

vier Teichkomplexen vor, besonders häufig in den Teichen auf der unteren Terrasse, *Scirpus lineolatus*, *Lysichiton camtschatense*, *Scheuchzelia palustris* und *Sparganium glomeratum* werden auch in den meisten Teichen gefunden. Während *Eleocharis palustris* nur auf der oberen Terrasse vorkommt, wächst *Carex nubigena* var. *albata* nur in den Teichen des Teichkomplexes II. Wir können Pflanzen, wie *Isoetes asiatica*, *Potamogeton polygonifolius*, *Phragmites communis*, und *Eriophorum gracile* als für den Teichkomplex III charakteristische Arten bezeichnen, weil sie nur darin vorkommen. Es ist zu betonen, dass die Teiche auf der untersten Stufe als Wasserpflanze nur eine Art, *Menyanthes trifoliata*, besitzen, während im Teichkomplex III eine grosse Anzahl verschiedener Arten vorkommt. Das ist teils auf die ökologischen Bedingungen, teils auf ihre Entwicklungsgeschichte zurückzuführen. Infolgedessen könnte man die oben erwähnte Ansicht wieder vorbringen, dass das dritte Teichgebiet zuletzt verlandet ist.

Ein Beispiel für die Ansiedlung von Landpflanzen gemäss der Austrocknung eines Teichs wird hier gebracht. Wie aus Abbildung 10 anschaulich zu ersehen ist, sind viele Wasser- und Landpflanzen, jede mit verschiedenem Areal, auf dem ausgetrockneten Unterboden des Teichs (T. IX) nebeneinander gemischt gewachsen. Das zeigt den Übergang der Teichgesellschaft zur Landgesellschaft.

Im folgenden sei nur kurz von den Eigenschaften einiger wichtiger Pflanzen gesprochen, da wir schon bei anderer Gelegenheit darauf gekommen sind. Wie in einer anderen Abhandlung noch näher berichtet werden wird, gehört diese Graswiese zur *Molinia-Eriophorum*-Assoziation, die reichlich mit *Geum pentapetalum*, *Narthecium asiaticum* und *Drosera rotundifolia* gemischt ist.

Molinia japonica, die ausgetrockneten Boden gut ertragen kann, nimmt gemäss der Entwicklung des Moorlandes die allmählich austrocknenden Stellen ein und geht in der Tat zum *Molinietum* über. KOCH (1920)[1] hat darauf hingewiesen, dass Moorboden, auf dem sich *Molinia coerulea*, eine ubiquitäre Art in Moorwiesen, ansiedelt, durch deren torfzersetzende Eigenschaft in milderen Humus übergeführt wird. Die Frage, ob unsere *Molinia japonica* auch dieselbe Eigenschaft besitzt, muss derzeit noch unbestimmt bleiben; dieses Gras spielt jedoch bei der Torfbildung eine grosse Rolle. Nebenbei sei nur

[1] KOCH, W., zitiert in RÜBEL, S. 100.

noch bemerkt, dass der Boden bei *Molinietum* hier stark sauer ist und 4.5—4.8 pH ergab, während er bei europäischem *Molinietum* neutral ist oder nur schwach sauer reagiert. Man trifft in dem Grasmoore überall *Eriophorum gracile*, eine Art, die stets im Hochmoor, besonders im Bergmoor in unserem Lande vorherrscht. Es kommt auf durchnässtem Boden vor und beteiligt sich an der Torfbildung. In dem Teichgebiet tritt es homogenetisch auf beiden Seiden des Teiches auf. *Narthecium asiaticum* tritt auch reichlich auf durchnässtem Bestande auf, vor allem auf der unteren Seite des Teichs, und manchmal erstreckt sich sein Rhizom in den Teich und trägt stark zur Verlandung bei. Wo *Drosera rotundifolia* vorkommt, trifft man manchmal *Sphagnum* an, beide wachsen zusammen. Ihr Wohnort beschränkt sich aber in den meisten Fällen auf die innere Seite des oberen Randes eines Teichs. Das ist gewiss der Ausdruck der spezifischen Lebensansprüche dieser Pflanze. Dass das *Sphagnum* zum Gedeihen feuchter Luft bedarf, wurde oben schon erwähnt. *Geum pentapetalum* wächst reichlich auf der Böschungsseite des unteren Teichrandes, wo der Boden starkem Sonnenlicht ausgesetzt ist. Es bildet auf wenig durchnässtem Boden zusammen mit *Molinia japonica* überall eine *Molinia-Geum*-Assoziation, die in diesem Grasmoore allmählich die Vorherrschaft gewonnen hat. *Menyanthes trifoliata* ist die in den meisten Teichen dominierende Pflanze. Ihr Rhizom erstreckt sich sowohl auf den Unterboden als auch ans Ufer. Sie spielt eine grosse Rolle bei der Verlandung des Teiches, wie das in anderen Hochmooren in unserem Lande gewöhnlich der Fall ist, indem sie sich an der Entwicklung eines Schwingrasens beteiligt.

Nun seien die Pflanzen, die im Einzelbestand manchmal vorkommen, nach ihrem Stetigkeitsgrad aufgeführt: *Molinia japonica* (100)[1], *Eriophorum gracile* (98), *Geum pentapetalum* (97) und *Drosera rotundifolia* (83), von denen sich die ersten drei Arten in allen vier Gebieten immer als stete Pflanzen erweisen. *Narthecium asiaticum* (68) und *Sphagnum sp.* (60) sind dann die meist vorhandenen, während *Carex stellulata* (48), *Fauria Crista-galli* (42), *Calamagrostis sachalinensis*

[1] Die Zahlen in Klammern geben den Stetigkeitsgrad in Prozenten an, vergleiche hiermit Tabelle II am Schluss dieser Abhandlung.

(35), *Oxycoccus palustris* var. *intermedium* (33), *Shortia soldanelloides* var. *genuina* (30), *Scheuchzelia palustris* (23) und *Lysichiton camtschatense* (22) zuweilen oder nur selten vorkommen. Die anderen 21 Arten treten selten in diesem Teichgebiet auf. Sie gehören meist zu Elementen aus anderen Beständen, die sich mehr auf ausgetrocknetem Boden entwickeln.

Wie oben erwähnt, sind die ökologischen Bedingungen auf beiden Seiten eines Teichs nicht gleich, und infolgedessen lassen sich verschiedene Pflanzengesellschaften erkennen. Denn während sich auf der oberen Seite nur wenige Arten ansiedeln, tritt auf der unteren eine grosse Anzahl von Arten auf, und eine Art, die auf der oberen Seite eine stete Art ist, erweist sich auf der unteren nicht immer als vorherrschend und umgekehrt, wie aus der Tabelle II zu erkennen ist.

Es ist merkwürdig, dass man auf dem unteren Rand sowohl hygrophile als auch xerophile Pflanzen antrifft, in die die meisten zufälligen Pflanzen einzureihen sind. Das kommt aber daher, dass der Nässegrad entsprechend dem Steigen des Randes an jeder Stelle ganz verschieden ist und es dadurch verschiedene Pflanzen gibt, die zur ihrem Gedeihen voneinander abweichende Wasseransprüche machen.

Zum Schlusse dieser Abhandlung sei die Vegetation auf den vier Teichgebieten miteinander verglichen. Zunächst kehren wir noch einmal zum Stetigkeitsdiagramm zurück, da sich die Konstitution der Assoziation daraus anschaulich ergibt. In dem Gebiete I und II verbreitet sich jede Klasse annähernd gleich, m. a. W. man kann in diesen Beständen eine einheitliche Vegetation erwarten. Eine noch homogene Verbreitung der Arten besteht auch im Gebiet IV, wo die meisten (5 Arten unter 10) der höchsten Klasse angehören und die nächste fehlt. Das Diagramm des Gebiets III zeigt deutlich uneinheitliche Verbreitung der Pflanzen, und zwar erweisen sich die meisten Arten (17 Arten unter insgesamt 31) als zufällige.

Bemerkt sei hier, dass die Artzusammensetzung des ersten Gebiets mit der des dritten etwas Ähnlichkeit hat. Ausser den steten und häufigen Arten, die in beiden gemeinsam vorkommen, können wir als zufällige Pflanzen in beiden *Ledum palustre* var. *nipponicum*, *Diplycosia adenothrix* und *Heloniopsis breviscapa* finden. Das Verhältnis zeigt sich noch inniger durch den Gemeinschaftskoëffizienten. Unter

Gemeinschaftskoëffizient verstehen wir nach JACCARD (1928, S. 170)[1] das prozentuale Verhältnis zwischen der Anzahl der Arten, die zwei Vergleichsgliedern gemeinsam sind, zur Gesamtzahl der Arten, die auf oder in beiden vorkommen. Wie sich aus folgender Tabelle ergibt,

Gemeinschaftskoeffizient.

I-II	I-III	I-IV	II-III	II-IV	III-IV
46%	53%	41%	45%	60%	32%

schwankt der Koëffizient zwischen 32 und 60%, je nach dem Grad der ökologischen Analogie. Er beträgt 60% zwischen den Gebieten II und IV und 53% zwischen I und III. Der hohe Koëffizient zwischen den Gebieten II und IV beruht auf ihrem ziemlich ausgetrockneten Boden, während der zwischen den Gebieten I und III in der ähnlichen Struktur des Teichs zu suchen ist. Erwähnt sei noch, dass der Koëffizient zwischen den Gebieten I und III 53% zeigt, die dicht beieinander liegenden Gebiete II und III ergeben nur 45%, weil sie einen verschiedenen Wasserversorgungsgrad haben. Dass sich der geringste Wert zwischen den Gebieten III und IV ergibt, stimmt damit überein, dass das eine einheitliche Vegetation und das andere uneinheitliche zeigt. Der Gemeinschaftskoëffizient stimmt im grossen und ganzen mit der Verschiedenheit des morphologischen Baus und der Entwicklungsgeschichte des Teichgebiets sowie der Wasserversorgung überein, wovon wir oben wiederholt gesprochen haben.

Vorliegende Arbeit wurde teilweise durch Unterstützung der Saito-Gesellschaft Hoonkwai durchgeführt. Dafür spreche ich auch hier meinen herzlichen Dank aus. (Y. YOSHII).

VII. ZUSAMMENFASSUNG.

1) Der Kegelberg Ôdake trägt auf einem westlichen Abhang in Abstufungen zwei ausgedehnte, flache oder schwach geneigte Terrassen, auf denen sich Grasmoore entwickeln, die sich dadurch auszeichnen,

[1] JACCARD, P., l. c.

dass eine grosse Anzahl kleiner Teiche mit aufgewölbtem Rand hier und da auf ihnen zerstreut ist.

2) Das Profilbild des Moorbodens bestätigt, dass sich die Moore auf vulkanischer Asche entwickelt haben, und ferner, dass vielfache Ausbrüche des Vulkans in kurzen oder langen Zwischenräumen stattgefunden haben.

3) Die ausgeworfene, vulkanische Asche wurde auf den Terrassen abgelagert und später so hart zusammengepresst, dass sie kaum Wasser durchlässt. Durch Stagnierung des Sickerwassers in der Senke auf dem Aschendoden, begünstigt durch kaltes Bergklima, setzte Torfbildung ein.

4) Man kann die Moore daher genetisch in die Kategorie der Quellmoore einreihen Unter Quellmoor versteht man aber gewöhnlich solche, die auf nährstoffreichem, besonders kalkreichem Gelände entstehen und folglich mit eutrophen Pflanzen bewachsen sind. In unserem Falle ist es aber ganz anders; die Moore sind auf saurem, nährstoffreichem Aschenboden aus oligotrophen Pflanzen entstanden, wie das bei Hochmooren vorkommt, aber es lässt sich hier keine Wölbung von *Sphagna* erkennen. Sie sind daher nach KOPPE in die Reihe der primären, oligotrophen Moore zu stellen.

5) Die kleinen Teiche, die durch einen ausgeprägt aufgewölbten Rand ausgezeichnet sind, werden in folgender Weise gebildet: An den Stellen, wo horizontaler oder schwach geneigter Moorboden plötzlich seine Neigung verändert, tritt Quellwasser aus. Infolgedessen tritt dort üppige Vegetation auf und schreitet die Torfbildung fort, wodurch Ablagerung des Torfs um den Quellpunkt herum zunimmt. Mit dem Emporsteigen des Randes füllt das Quellwasser den Teich aus, und je höher das Wasserniveau steigt, desto höher wölbt sich der untere Rand, wobei seine Unterlage stets von Teichwasser durchnässt ist und ihn zu weiterem Wachstum der Pflanzen veranlasst.

6) Die Teichgebiete werden je nach ihrer Lage und Entwicklungsgeschichte in vier Gruppen eingeteilt; während sich die eine auf der oberen Terrasse befindet, liegen die anderen drei auf der unteren, von denen zwei Gebiete ganz nahe nebeneinander gruppenweise am Fuss der steilen Böschung zwischen den beiden Terrassen liegen.

7) Der früher im Teichgebiet liegende See muss verhältnismässig seichten Unterboden und sumpfiges Ufer besessen haben, so dass viele

sumpfige Pflanzen oder Wasserpflanzen darin gut gedeihen konnten. Das Überwachsen und die Ablagerung sowohl ans Ufer wie auch ins Innere ist so lange erfolgt, bis der See mit Torfmoor bedeckt war, während um die Quellpunkte herum das freie Wasser als kleine Teiche noch erhalten blieb. Eine Reihe kleiner Teiche (Trichter nach OSVALD) lässt sich auf dem geneigten Boden auf jedem Teichgebiet erkennen. Sie sind höchstwahrscheinlich Reste einer Bachrinne, die aus dem oberen See abfloss.

8) Um die Konstitution der Pflanzengesellschaft am Teich zu erkennen, benutzen wir die Methode der Standortsaufnahme. Die damit erzielten Ergebnisse zeigen, dass die beiden Seiten eines Teiches verschiedene Vegetationseinheiten liefern. Besonders abweichende Verschiedenheit lassen die Teiche erkennen, die einen aufgewölbten Rand besitzen. Während auf der oberen Seite wenige Arten vorkommen, siedeln sich auf der unteren viele an. Das ist in den verschiedenen ökologischen Bedingungen, besonders in der abweichenden Wasserversorgung an jeder Stelle, entsprechend dem Emporsteigen des Randes, begründet.

9) Die Pflanzen an den Teichen lassen sich nach dem Stetigkeitsgrad folgendermassen ordnen: *Molinia japonica*, *Eriophorum gracile*, *Geum pentapetalum*, *Drosera rotundifolia*, *Narthecium*, *asiaticum*. Die ersten drei sind stete Arten. Im Teiche wächst üppig *Menyanthes trifoliata*, sie kommt in den meisten Teichen vor.

10) Die Physiognomie aller vier Teichgebiete ist annähernd gleich, sogar dieselben Arten kommen stetig vor, aber die Artzusammensetzung auf jedem einzelnen ist ziemlich verschieden voneinander. Durch das Konstitutionsdiagramm kann man die Verschiedenheit der Artverbreitung auf jedem Teichgebiet deutlich erkennen. Der Gemeinschaftkoëffizient zwischen je zwei Teichgebieten stimmt im ganzen mit dem Grad ihrer ökologischen Ähnlichkeit überein.

11) Nach den verschiedenen ökologischen Bedingungen kann man zwei verschiedene Bestände auf dem Teichgebiet, besonders ausgeprägt im Gebiet III, erkennen: der eine besitzt relativ wenige Elemente, die hauptsächlich auf sumpfigem Standort auftreten, der andere umfasst viele Arten, die auf ausgetrocknetem Gelände vorkommen. Während die ersten Arten als Relikte der Teichvegetation anzusehen sind, stellen die letzten solche dar, die sich nach dem Austrocknen des Bodens aus anderen Beständen hier angesiedelt haben.

Tabelle I[1] Bau jedes Teichs

A	Breite in der Böschungsrichtung
C	Breite, senkrecht zur Böschung
M	die grösste Breite
B	Breite des Randes
O	schiefe Fläche
H	Höhe des Randes
L	Tiefe vom Mund bis zur Wasseroberfläche
D	Wassertiefe
S	Schlammtiefe
Iu	Böschungswinkel auf der unteren Seite
Io	Böschungswinkel auf der oberen Seite
R	Winkelgrad

		A	C	M	B	O	H	L	D	S	Iu	Io	R
I. Teichgebiet	I	390	290	460	25	40	23	37	73–30	0-12	20	20	300°
	II	240	300	—	20	60	28	20	20–37	27–37	25	60	280°
	III	—	—	—	40	90	42	19	26	56	45	5	285°
	IV	110	220	280	35	35	10	19	15	55	70	5	230°
	V	640	300	670	25	90	53	22	50	20	68	10	252°
	VI	560	220	—	40	130	59	22	36	39	70	5	250°
	VII	760	250	—	20	50	35	36	0–20	34	45	20	280°
	VIII	320	195	—	20	45	24	25	0–85	43	85	85	280°
	IX	580	440	—	50	30	12	55–57		27–33	85	85	280°
	X	80	95	—	25	30	10	32		43	30	45	295°
													230°–300°
	XI	140	120	—	—	—	—	23	14–29	65–55	100	100	288°
	XII	1200	800	1460	—	—	—	16	—	—	40	0	250°
	XIII	170	480	—	—	—	—	15	7.5	62.5	30		308°
	XIV	500	220	730	—	—	—	18	19	42	30	20	308°
	XV	300	660	1035	—	—	—	18–0	10	57	30		308°

II. Teichgebiet	XVI	340	400	—	30	35	5	15	0	90–130	90		—	260°
	XVII	330	370	—	—	—	—	16	78–76	0–2	—		—	260°
	XVIII	370	500	—	—	—	—	17–22	100	0	*100*		*90*	260°
	XIX	150	170	—	—	—	—	18	92	8	—		—	260°
	XX	180	380	—	—	—	—	18	38	27		15		260°
	XXI	260	160	—	—	—	—	22	0–51	60–0		30		260°
	XXII	280	230	—	—	—	—	27	0–37	70–23		30		260°
	XXIII	240	400	—	—	—	—	22	53	9–13		15		260°
	XXIV	225	420	—	—	—	—	18	22–55	41–2	*35*		*15*	260°
	XXV	530	510	—	—	—	—	18	0–55	30–57	*65*		*5*	275°
	XXVI	140	200	—	—	—	—	31	5	45	*70*		*35*	260°
	XXVII	70	100	—	—	—	—	23	12	61	*105*		*30*	276°
	XXVIII	280	190	—	—	—	—	19–22	50, 60	64, 80	*65*		*30*	276°
	XXIX	250	330	—	—	—	—	21	53	4		60		276°
	XXX	115	165	—	—	—	—	20	25–31	10–4	30		60	276°
	XXXI	130	100	—	—	—	—	29	9	38		30		275°
	XXXII	110	165	—	—	—	—	20–25	21	12		50		275°
	XXXIII	90	70	190	—	—	—	26–28	11	29		40		260°
	XXXIV	150	80	230	—	—	—	25	14–23	25–16		40		260°
														260°–308°
	XXXV	700	1800	—	25	100	18	20	55	7		35		290°
	XXXVI	140	310	—	35	150	21	31		14	*40*		*10*	295°
	XXXVII	700	710	1170	45	90	40	24	12	72	*80*		*5*	275°

[1] Vergl. hiermit die Skizze eines Teichs (Fig. 3 auf S. 314). Die Teiche wurden im Juli 1930 gemessen.

III. Teichgebiet

	A	C	M	B	O	H	L	D	S	Iu	Io	R
XXXVIII	325	960	—	30	110	30	21	26	73	*100*	*20*	272°
XXXIX	950	1710	—	30	120	17	17	29	23	30	—	280°
XL	380	940	—	—	—	—	18	6–38	45–18	—	5	280°
XLI	1200	1670	—	—	—	—	17	17–38	32–31	—	—	280°
XLII	400	730	—	—	—	—	19	24–49	30–20	—	60	280°
XLIII	220	310	—	30	120	40	25	56	3	*70*	*35*	280°
XLIV	130	200	—	20	47	20	17	0–1	58–59	115	—	290°
XLV	160	240	—	—	—	—	27	21	34	—	140	290°
XLVI	370	890	—	30	60	19	18	29	34	*140*	*60*	290°
XLVII	190	500	—	—	—	—	21	24	25	—	60	300°
XLVIII	180	225	—	—	—	—	26	3	49	—	—	300°
XLIX	120	350	—	55	50	15	21	5	33	*40*	*30*	290°
L	180	480	—	25	30	9	23	10	46	*60*	*30*	290°
LI	155	355	—	—	—	—	21	10	47	40	90	300°
LII	210	460	—	55	110	21	18	17	53	*70*	*40*	310°
LIII	160	280	—	—	—	—	19	20	34	105	200	310°
LIV	120	620	—	25	45	17	25	21	21	35	140	275°
LV	250	510	—	30	50	22	25	20	42	50	65	275°
LVI	90	520	—	35	35	17	29	21	15	*70*	*15*	265°
LVII	390	240	440	40	90	13	26	0–50	11–8	30	—	280°
LVIII	190	225	—	30	40	20	22	31	45	*40*	*25*	275°
LIX	260	170	—	40	35	23	22	56	35	*135*	*30*	280°
LX	440	300	—	30	35	24	25	28	52–8	*85*	*40*	295°
LXI	310	260	—	45	30	25	26	18–32	30–57	80	80	295°

	LXII	130	135	—	25	60	13	22	18	12	45	55	285°
	LXIII	150	770	—	—	—	—	20	3–10	25	—	10	310°
	LXIV	1380	950	—	60	40	21	21	10–19	22–10	0	—	310°
	LXV	280	185	—	40	70	19	21	0–9	41–50	0	10	310°
													265°–310°
IV. Teichgebiet	LXVI	25 (A_1)	32 (A_2)	—	37	45	12	22	39	35	30	—	262°
	LXVII	55 (A_1)	90 (A_2)	—	60 (B_1)	55 (O_1)	20	22	44	27	*125*	*30*	262°
	LXVIII	260	310	360	35	70	37	22		23	80	80	240°
	LXIX	200	300	310	50	95	34	24	3–15	25–13	*100*	*20*	255°
	LXX	110	90	—	—	—	—	10	38	27	—	—	280°
	LXXI	90	70	—	—	—	—	8	40	25	—	—	280°
	LXXII	40	60	—	—	—	—	9	42	24	—	—	280°
	LXXIII	40	—	—	—	—	—	21	39	+	—	—	280°
	LXXIV	375	160	—	60	25	7	18	15–66	62–4	*45*	*20*	270°
	LXXV	165	140	—	130	60	13	18	12–61	83–21	*65*	*20*	275°
	LXXVI	120	200	230	—	—	—	18	0–3.5	36.5–40	15	30	280°
	LXXVII	50	200	—	—	—	—	14		76	30	30	280°
	LXXVIII	1745	1705	—	15	30	20	11	—	—	*110*	*45* 510	256°
													240°–280°

ERKLÄRUNG DER TAFELN VIII-XI

Fig. 1. Im Vordergrunde ein Grasland auf der unteren Terrasse. Im mittleren Teil ein steiler Abhang zwischen der oberen und der unteren Terrasse. Im Hintergrunde steht Berg Ôdake.

Fig. 2. Grasmoor auf der unteren Terrasse, darauf einige Teiche mit ausgeprägt emporsteigendem Rand. Im Mittelgrund liegt Teich LIV.

Fig. 3. Ein ausgetrockneter Teich IX, dessen Rand mit Sträuchern und Gräsern bewachsen ist. Vergl. hierzu die Skizze, Fig. 10 im Text.

Fig. 4. Teich XXXV im Teichgebiet III, liegt ganz am Fuss des Abhangs, auf dem üppiges Gehölz steht. Im Teich wächst *Potamogeton polygonifolius*.

Fig. 5. Teichgebiet III. Vom Abhang aus photographiert. Eine grosse Anzahl von Teichen liegt nebeneinander.

Fig. 6. Teichgebiet II. Vom Abhang aus photographiert. Das Grasland erstreckt sich auf die untere Terrasse.

Fig. 7. Ein Teil des Teichgebiets III. Vom Vordergrund nach hinten liegen Teiche XLVI, XLI und XXXIX.

Fig. 8. Teich XLIX. Im Vordergrund *Menyanthes*-Assoziation im Teich. Im Hintergrund Strauchgebüsch von *Pinus pumila*.

Fig. 9. Teich LXI. Ansicht von oben. Im Hintergrund Buschwerk von *Abies Mariesii*.

Fig 10. Seitenansicht des Teichs LX im Teichgebiet III. Deutliche Aufwölbung des untersten Randes.

Fig. 11. Ansicht nach Westen hin von der unteren Terrasse aus. *Narthecium*-Assoziation, liegten im Hintergrund einige Teiche.

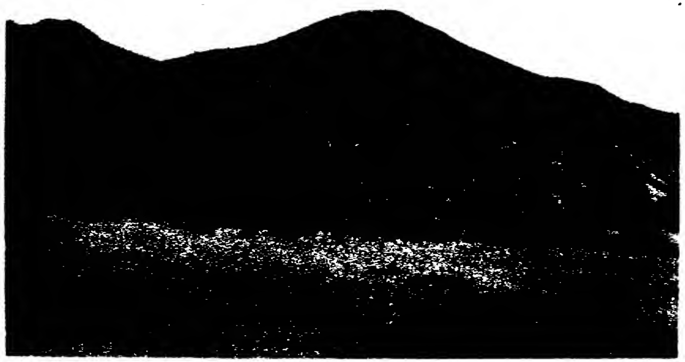
Fig. 12. Grasmoor auf der oberen Terrasse. Im Hintergrund zwei *Molinia*-Bulten und verstreut Strauchgebüsch.

Fig. 13. Teich III von unten gesehen. Im Vordergrund üppige Vegetation von *Molinia japonica*. Am oberen Rand erstreckt sich *Droserarotundifolia*. Im Teich *Menyanthes trifoliata*. Im mittleren Teil *Pinus*-gebüsch. Im Hintergrund *Abies*-Assoziation am Abhang.

Fig. 14. Teich I von unten gesehen. Im Vordergrund *Molinia japonica* und *Fauria Crista-galli*. Im Hintergrund *Pinus pumila*.

Fig. 15. Teich LI. Am schmalen Rand dominiert *Molinia japonica* und *Eriophorum gracile*. In der Mitte liegen viele Teiche hintereinander.

Fig. 16. Teich LVII. Ansicht nach Westen hin. Verlandung am rechten Rand. Im Teich findet sich *Sparganium glomeratum* und *Scirpus lineolatus* und hinter ihnen *Lysichiton camtschatense*, *Molinia japonica* und *Abies Mariesii*.



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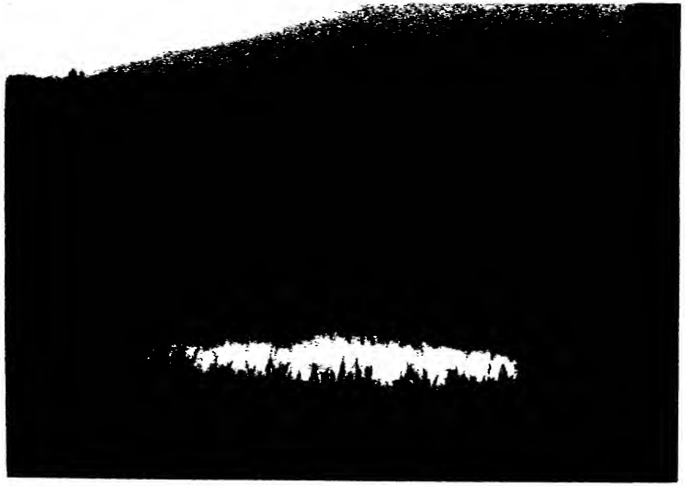

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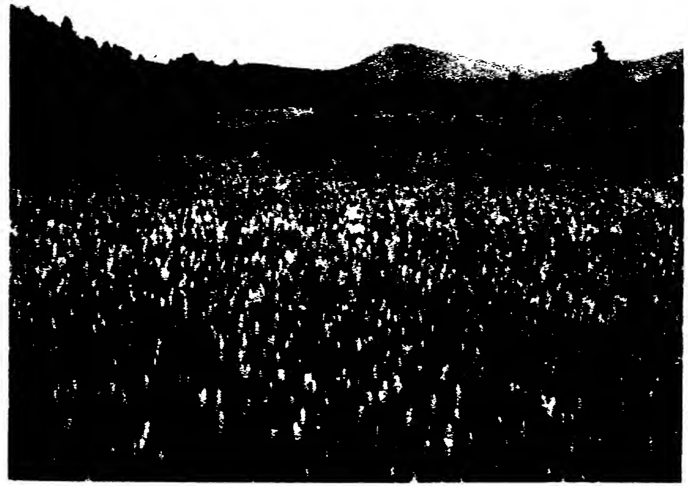

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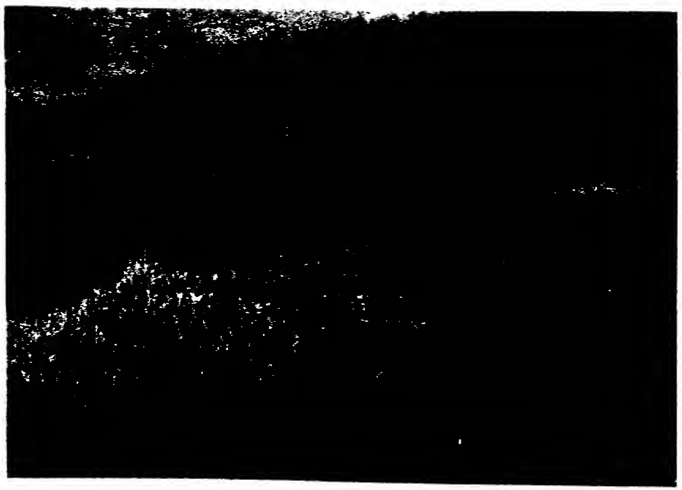

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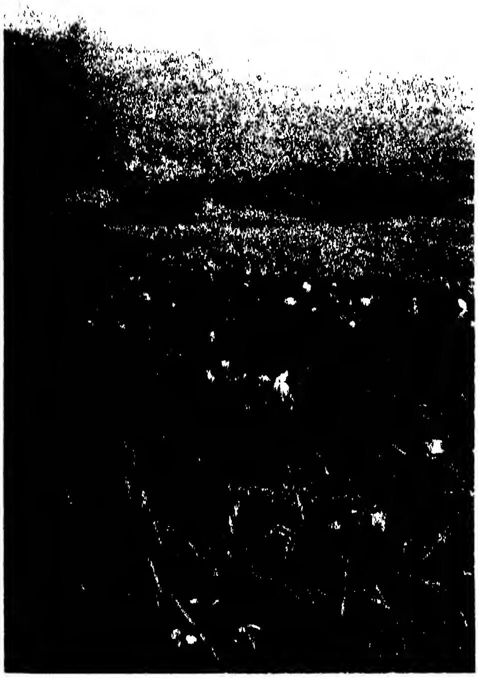
(Hayasi photo.)



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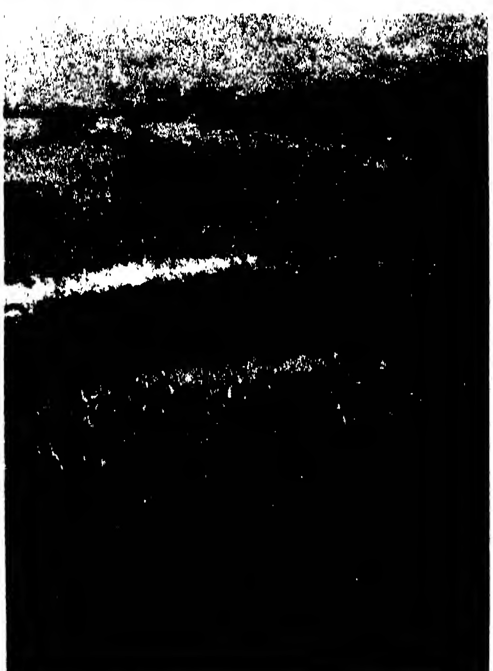

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(Hayasi photo.)

Y. Yoshii und N. Hayasi: Botanische Studien subalpiner Moore.

The Power of the Adductor Muscle of the Lamellibranchs, Inhabiting in the South Sea Islands.*

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(With 1 text-fig.)

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INTRODUCTION.

The study of the adductor muscle of bivalves is of interest not only from the stand point of muscle physiology but also from the ecological view point of marine animals. Accordingly, many physiologists have focused their interests upon this problem, and have published many papers. CH. DARWIN (1845) noticed that the large Tridancna, an inhabitant of tropical seas, has a very powerful muscle. LEON VAILLANT (1865) studied the power relation of the adductor muscle of *Tridacna elongata*, and found that it has the absolute power of 4919 gms.–7200 gms. per sq. cm. of section area of the adductor muscle. PLATEAU (1884) studied the power of the adductor muscle and of the ligament of 15 species of bivalves, and found that a wide range of differences exists in this regard among many species of Lamellibranchs. Further, he (1885) investigated the muscle power of the craw of crabs and compared the power with those of the frog and human muscles. The present writer (1929) also conducted an experiment on the power of the adductor muscle and of the ligament, using seven common bivalves found in the vicinity of the Marine Biological Station at Asamushi, and in addition observed the spontaneous shell movement of the oyster, with or without loading with various weights. The primary object of the present investigation was the determination of the power of the adductor muscle and ligament of 30 species of bivalves which were collected in tropical seas.

* Contributions from the Marine Biological Station, Asamushi, Aomori-Ken. No. 65.

Secondary, however, the purpose was extended to include a study of the time needed in tearing off the adductor muscle of the oyster, *Ostrea dendata* KUSTER, by a hung weight. The results thus obtained were compared with those of my former investigation in view of comparing the tropical oyster with a temperate one. The experiments were carried out from October (1929) to February (1930) at the islands of Yap and Palau. As these islands are small oceanic islands, encircled with coral reef, the temperature of the sea water showed only a very slight variation, ranging between 27°–30°C. throughout the year.

The author takes this opportunity of expressing his sincere thanks to Prof. S. HATAI and Assist. Prof. S. KOKUBO for their valuable suggestions and criticisms given in the course of this study. Thanks are also due to the Governer and officers of the South Sea Islands for their courtesy and financial aid, and I am much indebted to Mr. T. KURODA, who identified most of the species of the Lamellibranchs employed in the present investigation.

MATERIALS AND METHOD.

The materials used were 30 species of bivalves as listed below:

Species.	Locality.	Japanese name.
Monomyaria.		
Chlamys radula (LINNÉ).	Yap.	Rükühiaugi.
Hippoppus hippoppus LINNÉ.	Yap and Palau.	Shagö.
Lima (Ctenoides) tenera SOWERBY.	Yap.	Midarehanegai.
Ostrea dendata KUSTER.	Palau.	
Pinctada margaritifera LINNÉ.	Palau.	Kurochogai.
Pteria macroptera LAMARCK.	Palau.	Mabe.
Spondylus spectrum (?) REEVE.	Yap.	
Tridacna crocea LAMARCK.	Palau.	Himejako.
Tridacna elongata LAMARCK.	Yap.	Nagajako.
Tridacna squamosa LAMARCK.	Palau.	Hirejako.
Heteromyaria.		
Lithophaga gracilis PHILIPPI.	Yap.	Kuroiroshiginohashi.
Lithophaga straminea REEVE.	Yap.	Warairoshiginohashi.
Septifer bilocularis LINNÉ.	Palau.	Kujakugai.

Species.	Locality.	Japanese name.
Isomyaria.		
Anadara antiqua (LINNÉ).	Yap.	
Asaphis deflorata (LINNÉ).	Yap.	Rükümasho.
Atactodea striata GMELIN.	Yap.	Isohamaguri.
Barbatia fusca (SOLANDER).	Palau.	Beniigai.
Cardium subrugosum SOWERBY.	Yap and Palau.	
Chama imbricata BRODERIP.	Yap.	Shiroinko.
Coralliophaga coralliophaga (GMELIN).	Yap.	Tagasode.
Gafrarium gibbium (LAMARCK).	Yap.	Inamigai.
Gafrarium pectinatum (LINNÉ).	Yap.	Hososujiinamigai.
"*Gari togata*" DESHAYES (var.).	Yap.	
Lucina philippiana REEVE.	Yap.	
Marcia (*Hemitapes*) *striata* (GMELIN).	Yap.	Sudarehamaguri.
Paphia (*Ruditapes*) *variegata* (SOWERBY).	Yap.	Himeasari.
Paphia (*Tapes*) *litterata* (LINNÉ).	Yap.	Rüküasari.
Pitar crocea REEVE (var.)	Yap.	
Tellina rugosa BORN.	Yap.	Rüküshiratori.
Venus (*Antigona*) *puerpera* LINNÉ.	Yap and Palau.	

As the method of the experiments has been already mentioned (1929) I will give now only a short account regarding this subject. In determing the strength of the adductor muscle of bivalves, one of the shells was tightly fixed with a strong wire along the under side of an iron bar which was attached to an iron stand. In order to pull the adductor muscle vertically the weight was hung by means of a strong wire connected to the margin of the other shell. The power of the muscle was estimated in terms of the gram weight needed to pull the shells apart. The amount of weight 'W' acted on the adductor muscle was calculable by the following formula.

$$W = \frac{a}{b} w + S.$$

where 'a' is the distance in centimeters from the ligament to the middle point of a line which connects the two adductor muscles, except in the case of Monomyaria, in which it means the distance between the centre of the adductor muscle and the ligament; 'b' is the distance in centimeters from the ligament to the point where the weight was hung; 'w' shows the hung weight in gms; 'S' is the weight

of a shell, which acted as a weight. The power of the adductor muscle per sq. cm. of section area was calculated in this way.

The power of the ligament 'W" was also calculated by the same formula. But in this case 'w" is the weight needed to close the shells entirely. In order to observe the time needed to tear off the adductor muscle by hanging a weight, the shell loaded with weight was dipped into a jar which was filled with running sea water.

EXPERIMENT.

I. The time needed until the adductor muscle of the oyster is torn off by a hung weight.

Twenty five oysters were tested, being loading with varying weights of 1 kg. 2, 5, 10, 15, and 20 kgms. The experimental results are given in Table 1. The relation between the time needed to tear off the adductor muscle and the weight acted on the adductor muscle per sq. cm. of section area was shown in Fig. 1.

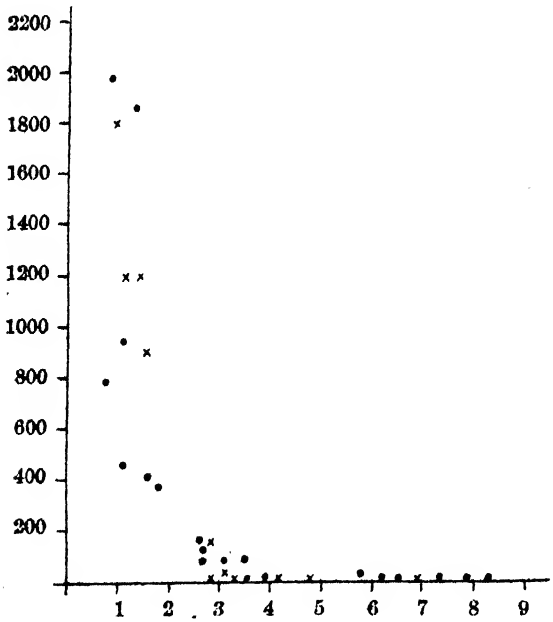

Fig. 1.
× *Ostrea circumpicta* PILS.
• *Ostrea dendata* KUSTER.
Ordinate — Duration of experiment in minutes.
Abcissa — Power acting on per sq. cm. section area of adductor muscle in kgs.

Although the results show some irregularity, the general rule that the time duration is longer when the weight is smaller and vice versa can be conceived from the above figure. As can be seen in No. 5 of Table 1, when the muscle was loaded with 9297 gms per sq. cm. of section area the time

TABLE 1.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Hung weight	W	W per. $\overline{cm}^2$	Duration	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	Kgs.	Kgs.	gms.	m.		
1	1160	17.0	9.0	20.0	4.5	5.35	5.5	10.5	10.0	19.09	3551	10	28C°.	Jan. 4 1930
2	690	15.0	7.0	17.0	2.7	3.60	5.5	11.0	15.0	30.00	8333	6	"	" 7 "
3	660	15.0	8.0	15.0	4.3	6.10	4.5	8.5	10.0	18.88	3095	80	"	" 4 "
4	570	16.0	9.0	18.0	3.5	5.50	5.5	9.5	5.0	8.63	1563	420	"	Dec. 30 1929
5	480	13.0	9.5	23.0	4.0	3.80	4.5	8.0	20.0	35.33	9297	1	"	Jan. 7 1930
6	477	17.0	8.0	23.0	4.5	4.60	5.0	9.0	20.0	36.00	7927	7	"	" " "
7	470	18.0	9.0	21.0	3.7	3.50	4.5	9.0	5.0	10.00	2714	80	"	Jan. 3 "
8	430	14.0	8.0	28.0	2.8	4.00	5.0	10.5	5.0	10.50	2625	153	"	Dec. 27 1929
9	430	13.0	9.0	15.5	3.2	2.80	5.0	9.5	2.0	3.80	1357	1860	"	" 28 "
10	390	15.0	9.0	20.0	5.5	5.60	6.0	11.0	20.0	36.66	6546	13	"	Jan. 7 1930
11	390	13.0	7.0	16.0	3.0	4.25	5.0	9.0	2.0	3.60	847	1980	"	Dec. 28 1929
12	370	13.0	8.5	18.0	2.5	2.90	4.5	9.0	5.0	10.00	3448	90	"	Jan. 3 1930
13	330	14.0	7.0	20.0	3.8	3.60	5.5	10.5	5.0	9.18	2716	120	"	" 4 "
14	330	13.0	9.4	17.0	3.4	3.10	5.0	9.5	20.0	38.00	12258	0	"	" 7 "
15	320	12.5	9.0	21.0	3.5	3.25	5.1	8.6	15.0	25.29	7781	13	"	" " "
16	310	13.0	7.0	17.0	3.0	3.00	4.5	8.5	10.0	18.88	6293	15	"	" " "
17	310	11.5	8.0	15.0	3.0	3.10	4.5	8.1	10.0	18.00	5806	28	"	" " "
18	300	12.0	8.5	21.0	3.5	3.50	4.5	8.5	15.0	28.33	8094	3	"	" " "
19	288	12.5	8.0	12.0	3.3	4.00	4.0	6.3	10.0	15.75	3937	20	"	" " "
20	285	14.0	8.0	20.0	4.5	4.10	5.0	9.5	1.0	1.90	463	6015	"	Dec. 28 1929
21	280	13.0	8.0	27.0	3.0	3.40	5.0	9.0	2.0	3.60	1068	480	"	" 30 "
22	260	12.5	7.5	18.0	3.2	3.30	3.5	7.0	1.0	2.00	606	8760	"	" 31 "
23	250	13.0	8.0	17.0	3.0	2.85	4.5	9.5	1.0	2.10	740	780	"	Jan. 4 1930
24	222	11.5	7.0	16.2	3.0	2.50	3.5	8.0	2.0	4.54	1816	370	"	Dec. 27 1929
25	185	11.0	6.0	12.0	2.0	2.00	4.0	8.5	1.0	2.12	1060	940	"	" 28 "

needed was 1 minute. To mention other cases it was 13 minutes by 7781 gms. in No. 15, 15 minutes by 6293 gms. in No. 16, 90 minutes by 3448 gms. in No. 12, 153 minutes by 2625 gms in No. 8, 420 minutes by 1563 gms. in No. 4, 6015 minutes by 463 gms. in No. 20, and 8760 minutes by 606 gms. in the case of No. 22. In my previous paper (1929), I observed the shell movement of the oysters of Asamushi, *Ostrea circumpicta* loading them with various weights. NOZAWA (1929) studied the respiration of the oyster under loaded or unloaded conditions. He found that gaseous metabolism becomes much greater when the animal is loaded with 5 kgs. weights as compared with the case under normal conditions. KOBAYASHI (1929) estimated the lactic acid formed in the adductor muscle under loaded or unloaded conditions in the oyster. According to his study, the adductor muscle of the oyster consists of two distinct parts, namely the large muscle and the small muscle. His results showed that, under normal conditions, the large adductor muscle contained 0.0604% of lactic acid and the small adductor muscle contained 0.1012%. But when the animal was loaded, the lactic acid of the large adductor muscle increased to 0.117%, and that of the small adductor muscle increased to 0.1361%. COHNHEIM and V. UEXKÜLL (1912) studied the consumption of oxygen in the leech and found that, in an unloaded condition, the leech consumed 0.51 mg. of oxygen per individual per hour at 19°C. When, however, the leech was loaded with a weight of 13 gms. and 72 gms. the consumption increased to 6.4 mg. and 12 mg. respectively. COHNHEIM (1912) also obtained similar results in making a study on *Sipunculus*.

A tentative comparison showing the relation which exists between the toleration time and the hung weight in two oysters, *Ostrea circumpicta* and *O. dendata*, can be seen in Fig. 1. Although the figure apparently shows that the tropical oyster is stronger than the temperate one, such comparison may not be very adequate because of the difference of species of the oysters. TAKATSUKI (1929) made a study regarding the heart pulsation of these two species and found that the heart of the temperate oyster beats about 14 times per minutes at 20°C and it completely ceases when the water temperature sinks below 5°C, or rises above 45°C., while he found, in the tropical oyster, that it beats only about 8 times at 28°–29°C. and ceases its beat at a

TABLE 2.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus	Ligament to Point	Hung weight	W	W per. $\overline{cm^2}$	Water temp.	Date	
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm^2}$	c.m.	c.m.	kgs.	kgs.	gms.	C°.		
1	1050	17.0	10.5	31.0	7.5	7.80	7.0	12.0	41.0	70.3	9030	30	Nov. 28	1929
2	680	17.0	7.0	17.0	2.2	3.30	5.5	10.0	19.0	36.3	11000	,,	,, 27	,,
3	570	12.0	9.5	23.0	5.0	5.25	5.0	8.0	30.0	48.0	9530	,,	,, 23	,,
4	510	14.0	9.0	22.0	3.2	3.50	5.0	9.0	20.0	36.0	10280	,,	,, 27	,,
5	500	14.0	9.0	22.0	4.5	5.00	4.5	7.5	34.0	26.6	11320	,,	,, 26	,,
6	454	12.0	7.0	12.0	4.0	3.30	5.0	8.0	18.0	28.8	8730	,,	,, 23	,,
7	470	15.0	9.5	21.0	5.5	5.55	5.5	9.0	28.0	45.8	8180	,,	,, 27	,,
8	270	11.5	7.5	19.0	4.2	3.00	5.0	8.5	15.0	25.5	8500	,,	,, 26	,,
9	270	12.0	9.0	20.0	4.3	2.70	5.0	9.0	17.0	30.6	11360	,,	,, 23	,,
10	215	10.0	7.0	13.0	3.3	2.25	4.5	7.0	11.5	18.0	8000	,,	,, ,,	,,
Mean	498.9			20.0	4.37	4.18			23.35	39.56	9587			

TABLE 3.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus	Ligament to Point	Added weight	W′	W′ per. $\overline{cm^2}$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm^2}$	c.m.	c.m.	gms.	gms.	gms.	C°.	
1	570	16.0	9.0	18.0	3.5	5.50	5.5	9.5	1200	2072	376	28	Dec. 30 1929
2	500	14.0	9.0	22.0	4.5	4.50	4.5	7.5	1100	1820	403	30	Nob. 26 ,,
3	430	14.0	8.0	28.0	2.8	4.00	5.0	10.5	400	840	210	28	Dec. 27 ,,
4	390	13.0	7.0	16.0	3.0	4.25	5.0	9.0	1100	2450	569	,,	,, 28 ,,
5	300	12.0	8.5	21.0	3.5	3.50	4.5	8.5	400	753	215	,,	Jan. 7 1930
6	280	13.0	8.0	27.0	3.0	3.40	5.0	9.0	450	810	238	,,	Dec. 30 1929
7	270	11.5	7.5	19.0	4.2	3.60	5.0	8.5	700	1010	277	30	Nob. 26. ,,
8	260	12.5	7.5	18.0	3.2	3.30	3.5	7.0	650	1300	394	28	Dec. 31 ,,
9	220	11.5	7.0	16.2	3.0	2.50	3.5	8.0	550	1257	503	,,	,, 27 ,,
10	185	11.0	6.0	12.0	2.0	2.00	4.0	8.5	400	850	425	,,	,, ,, ,,
Mean	340			19.7	3.3	3.65			695	1316	361		

temperature below 9°C, or above 50°C.

II. The power of the adductor muscle and of the ligament of several bivalves.

1. *Ostrea dendata* KUSTER.

The materials used here were collected at Palau Island. The results of ten experiments which were made on different individuals of these materials are listed in Table 2.

The body weight of these specimens ranges from 215 to 1050 gms, and their average weight showed 498.9 gms. The weight needed in tearing off the adductor muscle as instantly as loaded was 23350 gms., in mean. In this case, the weight W acted on the adductor muscle was 39560 gms., in mean. Consequently, the power of the adductor muscle per sq. cm. of section area was estimated to be 8000 gms. to 11320 gms, showing a mean of 9587 gms. The ratio of average body weight to average W can be designated as 1 : 79.2. The power of the ligament which is acting on the adductor muscle per sq. cm. of section area was estimated to be 361 gms., in mean. The ratio of the power of the ligament to that of the adductor muscle was determind to be 1 : 26.5.

2. *Pinctada margaritifera* LINNÉ.

The materials were obtained from the Palau Pearl Cultural Station of Palau Bay. The results obtained from 11 specimens are given in Table 4.

The body weight of these specimens ranges from 235 to 870 gms, and their mean weight was 376.1 gms. The weight required in tearing off the adductor muscle instantly after loading was 23180 gms., in mean. The W calculated by the formula was found to be 51110 gms., in mean. The power of the adductor muscle per sq. cm. of section area was calculated to be 8690 gms., in mean. The ratio of the mean body weight to the average W can be shown as 1 : 135. The power of the ligament per sq. cm. of section area of adductor muscle was estimated to be 180 gms. The ratio of the power of the ligament to the power of the adductor muscle was 1 : 48., in mean.

3. *Pteria macroptera* LAMARCK.

The specimens were collected from the bottom of a derelicted ship in Palau Bay. The data were obtained from two specimens and are tabulated in Table 5.

TABLE 4.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Add. mus. power Hung w.	Add. mus. power W	Add. mus. power W per. $\overline{cm}^2$	Ligament power Added w.	Ligament power W′	Ligament power W′ per. $\overline{cm}^3$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	kgs.	kgs.	gms.	gms.	gms.	gms.	C°.	
1	870	18.0	20.5	140.0	29.0	12.3	7.0	15.0	39.0	83.57	7056				28	Jan. 21th 1930
2	450	15.0	15.0	63.0	15.0	7.0	5.0	12.0	22.0	48.80	6971				,,	,,
3	390	13.0	12.5	33.0	8.5	5.0	4.0	10.0	21.0	52.50	10500				,,	,,
4	373	12.0	12.5	32.0	9.0	5.9	4.0	9.0	24.0	54.00	9152				,,	,,
5	370	13.0	11.0	42.0	10.0	5.3	5.0	11.0	20.0	44.00	8471				,,	,,
6	323	13.0	12.0	63.0	15.0	7.0	4.5	9.5	23.0	48.55	6935	600	1260	180	,,	,,
7	310	12.0	11.5	42.0	10.0	6.0	5.0	10.0	28.0	58.00	9667				,,	,,
8	297	13.0	11.0	36.0	7.0	4.0	3.8	8.0	20.0	42.10	10522				,,	,,
9	270	13.0	12.0	38.0	8.5	5.5	4.0	10.0	20.0	50.00	9091				,,	,,
10	250	12.0	12.0	37.0	8.5	5.2	4.0	9.0	21.0	46.70	8980				,,	,,
11	235	12.0	12.0	29.0	7.0	4.0	4.0	8.0	17.0	34.00	8250				,,	,,
Mean	376.1			50.4	11.6	6.11			23.18	51.11	8690	600	1260	180		

TABLE 5.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of ann. mus.	Ligament to Add. mus.	Ligament to Point	Adductor muscle power Hung w.	Adductor muscle power W	Adductor muscle power W per. $\overline{cm}^2$	Ligament power Add. w.	Ligament power W′	Ligament power W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	grs.	grs.	$\overline{cm}^2$	c.m.	c.m.	grs.	grs.	grs.	grs.	grs.	grs.	C°.	
1	330.0	15.0	15.0	80.0	13.0	6.20	5.0	11.0	17000	37400	6032	290	638	102.9	28	Jan. 21th 1930
2	320.0	15.0	15.0	106.0	11.5	5.20	5.0	10.0	21000	42000	8076	250	500	96.1	,,	,,
Mean	325.0			93.0	12.3	5.70			19000	39700	7049	270	569	99.0		

TABLE 6.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Hung weight	W	W per. $\overline{cm}^2$	Water temp.	Date	
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	kgs.	kgs.	gms.	C°.		
1	900	15.0	11.0	100.0	11.0	4.25	4.0	9.5	7.5	17.8	3390	29	Dec. 9	1929
2	650	13.5	10.0	60.0	11.0	4.25	4.0	9.0	7.5	16.9	3970	,,	,,	,,
3	640	14.0	11.0	64.0	14.0	5.50	4.5	9.0	10.0	20.0	3630	,,	,,	,,
4	610	12.5	10.0	50.5	12.0	4.00	4.0	8.6	6.5	13.9	3490	,,	,,	,,
5	570	11.0	9.0	52.0	13.0	4.25	4.0	7.5	7.0	15.3	3600	,,	,,	,,
6	515	13.0	10.0	50.0	12.0	4.50	4.0	8.0	8.0	16.0	3550	,,	,,	,,
7	450	11.5	8.5	45.0	7.8	4.50	3.5	8.0	6.0	13.7	3380	,,	,,	,,
8	350	9.6	8.6	53.0	14.0	4.25	3.5	7.5	8.0	17.1	4020	,,	4	,,
9	320	10.0	8.0	37.0	8.0	3.25	3.0	7.0	5.0	11.7	3600	,,	9	,,
10	300	9.5	7.5	40.0	7.0	4.75	3.0	6.5	5.0	18.2	3790	,,	,,	,,
Mean	530			55.6	10.6	4.45			7.05	16.06	3642			

TABLE 7.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Added weight	W′	W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	C°.	
1	920	15.0	9.5	72.0	25.0	5.7	4.0	9.5	90	217	38.0	29	Dec. 4th 1929
2	545	12.0	9.5	53.0	15.2	5.5	4.0	8.0	180	360	65.4	,,	,,
3	420	10.5	8.5	50.0	13.0	4.2	4.0	8.0	200	400	90.0	,,	,,
4	372	11.0	8.5	44.0	10.0	4.0	3.5	7.0	140	251	62.7	,,	,,
5	370	10.5	8.0	54.0	13.0	4.0	4.2	7.5	70	120	30.0	,,	,,
Mean	526			54.6	15.2	4.7			136	269.6	57.2		

TABLE 8.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. $\overline{cm}^2$	Power of ligament Added w.	Power of ligament W′	Power of ligament W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	9.0	4.0	3.7	2.5	1.5	1.2	2.0	4.0				45	90	75	28	Dec. 20 1929
2	4.5	3.3	3.1	1.7	1.0	0.8	1.2	3.0	550	1375	1718				„	„ 23 „

TABLE 9.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Add. muscle power Hung w.	Add. muscle power W	Add. muscle power W per. $\overline{cm}^2$	Ligament power Added w.	Ligament power W′	Ligament power W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	6.3	3.5	2.5	2.8	0.8	0.50	1.0	3.3	330	1089	2178	15.0	44.0	80.0	28	Jan. 27 1930
2	4.3	3.4	2.5	2.3	0.8	0.40	1.0	3.2	300	960	2400	15.0	48.0	120.0	„	„
3	4.3	3.3	2.5	1.5		0.60	0.8	3.0	400	1500	2500	8.0	30.0	50.0	„	„
4	2.6	2.6	1.8	0.6		0.30	0.7	2.5	250	892	2973	15.0	53.5	178.0	„	„
5	2.6	2.5	1.9	1.0		0.30	0.6	2.4	300	1200	4000	8.0	32.0	106.6	„	„
6	2.5	2.7	1.6	1.3		0.25	0.8	2.4	250	750	3000	10.0	30.0	120.0	„	„
7	2.4	2.2	1.6	1.0		0.25	0.7	2.1	350	1050	4200	15.0	45.0	180.0	„	„
8	2.0	2.2	1.6	0.7		0.25	0.6	2.0	270	900	3600	10.0	33.0	132.0	„	„
9	1.6	1.9	1.4	0.7		0.20	0.5	1.7	250	850	4250	8.0	27.0	135.0	„	„
10	1.5	1.7	1.2	0.6		0.20	0.5	1.7	230	782	3910	10.0	34.0	170.0	„	„
Mean	3.0			1.25					293	997	3268	11.4	37.6	127.2		

The body weight was 325 gms., in mean, w required 19000 gms. in the average and the W was calculated to be 39700 gms. The power of the adductor muscle per sq. cm. of section area was estimated to be 7049 gms. The power of the ligament acting on the adductor muscle per sq. cm. of section area was calculated to be 99 gms. The ratio of mean body weight to average W can be shown as 1 : 124, and of the ligament power to the adductor muscle power was found to be 1 : 71.

4. *Spondylus spectrum* (?) REEVE.

The experimental materials were obtained from Yap Island. The power of the adductor muscle, observed in ten tests, is given in Table 6.

The body weight of the specimens varied from 300 gms. to 900 gms. The weight used was 7050 gms., in mean. The W calculated by the formula was 16060 gms., in mean. The power of the adductor muscle was estimated to be 3642 gms., in mean. The ratio of the mean body weight to the mean W was 1 : 30.3. The power of the ligament, determined from five specimens, was shown in Table 7.

It was found from these results that the power of the ligament per sq. cm. of section area of adductor muscle was measured to be 57.2 gms. The ratio of the power of the ligament to the power of the adductor muscle was 1 : 65.

5. *Chlamys radula* (LINNÉ).

The data obtained from two specimens collected at Yap Island were listed in Table 8. The body weight of the specimens was 4.5 gms. The hung weight was 550 gms. The power of the adductor muscle was calculated to be 1718 gms. per sq. cm. section area. The power of the ligament was measured to be 75 gms. The ratio of the body weight to the W was 1 : 305. The ratio of the power of the ligament to the power of the adductor muscle was 1 : 22.

6. *Lima (Ctenoides) tenera* SOWERBY.

Materials were collected at Yap. The results obtained from ten specimens are given in Table 9.

The body weight of the specimens used was 1.5 gms. to 6.3 gms., showing a mean of 3.0 gms. The weight used was 293 gms., in mean. The W calculated by the formula was 997 gms., in mean. The power of the adductor muscle was measured to be 3268 gms., in mean. The power per sq. cm. section area of the adductor musle was calculated

TABLE 10.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Hung weight	S	W	W per. $\overline{cm^2}$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm^2}$	c.m.	c.m.	kgs.	gms.	kgs.	gms.	C°.	
1	4500	27.0	16.0	895	86	13.5	9.5	14.0	32.0	1200	48.80	3577	29	Jan. 9th 1930
2	3100	22.0	15.0	300	56	10.0	8.0	12.0	25.0	800	38.30	3830	,,	,,
3	3000	26.0	16.0	450	56	10.0	9.0	13.0	22.0	780	32.48	3248	,,	,,
4	2000	21.0	15.0	340	47	7.5	8.0	12.0	21.0	600	32.10	4280	,,	,,
5	1900	21.0	15.0	256	43	7.4	7.0	12.0	23.0	600	40.00	5405	,,	,,
6	1800	24.0	16.0	290	40	10.5	8.0	13.0	28.0	570	46.07	4387	,,	,,
7	1500	22.0	14.0	245	48	10.0	8.0	12.0	23.0	460	37.76	3776	,,	,,
8	1430	17.0	13.0	203	28	6.5	7.0	11.0	15.0	450	23.95	3684	,,	,,
Mean	2432			372.3	55	9.4			23.6		37.37	4023		

TABLE 11.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Added weight	S	W′	W′ per. $\overline{cm^2}$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm^2}$	c.m.	c.m.	gms.	gms.	gms.	gms.	C°.	
1	6800	30.0	21.0	1200	68	11.0	10.0	16.0	900	1100	2540	230	29	Jan. 9th 1930
2	6000	26.0	20.0	1150	112	15.5	9.5	16.0	1500	1800	4312	278	,,	,,
3	5000	32.0	20.0	750	70	12.0	11.0	16.0	900	1600	2909	242	,,	,,
4	4600	29.0	18.0	750	68	11.0	10.0	16.0	900	1100	2540	230	,,	,,
Mean	5510			962	88	13.6			1062		3270	239		

to be 127 gms. The ratio of the mean body weight to the W was 1 : 332, and of the power of the ligament to the power of the adductor muscle was 1 : 33.

7. *Tridacna squamosa* LAMARCK.

The specimens were collected at Palau Bay. The power of the adductor muscle observed in 8 specimens is shown in Table 10. The body weight ranged from 1430 gms. to 4500 gms. and its mean was 2432 gms. The hung weight used was 23600 gms., in average. The W calculated by the formula was 37370 gms., in mean. The power of the adductor muscle was calculated to be 4023 gms. per sq. cm. section area. The ratio of the body weight to the W was 1 : 14.3. The power of the ligament per sq. cm. section area of adductor muscle was observed in four tests and the results showed 239 gms., as can be seen in Table 11. The ratio of the power of the ligament to the power of the addictor muscle was 1 : 16.8.

8. *Tridacna elongata* LAMARCK.

The materials were collected in Yap Island, and the data obtained from nine tests are given in Table 12. The weight of the entire body was 857 gms., in mean. The hung weight was 24810 gms., in average. The total weight acting on the adductor muscle by hung weight and the weight of the shell itself was calculated to be 34840 gms., in mean. The power of the adductor muscle was 5294 gms. The ratio of the mean body weight to total W was 1 : 27.2. The power of the ligament per sq. cm. section area of adductor muscle was determined to be 196 gms. The ratio of the power of the ligament to that of the adductor muscle was 1 : 27.

9. *Tridacna crocea* LAMARCK.

The data obtained from three specimens which were collected in Palau are shown in Table 13.

The body weight ranged from 230 to 300 gms. The weight needed to tear off the adductor muscle instantly after loading was 15000 gms., in mean. The W calculated by the formula was 22100 gms., in mean. The power of the adductor muscle was 7530 gms. per sq. cm. of section area. The ratio of the average body weight to the W was 1 : 86. The power of the ligament was estimated to be 266 gms. The ratio of the power of the ligament to that of the adductor muscle was 1 : 28.3.

TABLE 12.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	S 1 shell weight	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. cm^2	Power of ligament Add. w.	Power of ligament W′	Power of ligament W′ per. cm^2	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	cm^2	gms.	c.m.	c.m.	kgs.	gms.	gms.	gms.	gms.	gms.	C°.	
1	1950	19.5	11.5	310	87.0	11.5	674	7.5	10.5	44.0	62274	5415				28	Feb. 13. 1930
2	1106	17.5	10.0	135	30.0	7.4	410	6.5	9.0	28.5	39871	5387				,,	,,
3	1105	17.0	9.9	200	53.0	7.8	400	6.5	9.0	35.0	48636	6235	1000	1784	228	,,	,,
4	760	15.5	8.5	115	32.0	7.0	252	6.0	8.0	24.5	32918	4702	900	1452	207	,,	,,
5	750	15.5	9.5	110	35.0	7.0	275	6.0	8.5				700	1262	180	,,	,,
6	600	14.5	8.5	102	34.0	6.0	253	5.5	7.5	20.0	27525	4587				,,	,,
7	532	13.5	8.5	85	33.0	6.0	187	5.2	7.5	25.0	36244	6040				,,	,,
8	380	12.0	7.0	65	22.0	4.2	145	4.5	6.5	16.0	23256	5537	400	722	171	,,	,,
9	85	8.0	5.5	15	6.5	1.8	31	3.1	4.5	5.5	8014	4452				,,	,,
Mean										24.81	34840	5294	750	1305	196		

TABLE 13.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	S 1 shell weight	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. cm^2	Power of ligament Added w.	Power of ligament W′	Power of ligament W′ per. cm^2	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	cm^2	gms.	c.m.	c.m.	kgs.	kgs.	gms.	gms.	gms.	gms.	C°.	
1	300	11.0	7.0	65	13.0	3.1	104.0	4.0	6.5	18.0	24.20	7806	500	812	265	28	Jan. 21 1930
2	240	10.0	7.0	55	10.0	2.8	70.5	4.0	6.5	13.0	21.12	7543	550	893	319		,,
3	230	9.5	7.0	46	10.0	2.9	70.0	4.0	6.0	14.0	21.00	7241	500	625	215		,,
Mean	256			55.3	11.0	2.9				15.0	22.10	7530	516	743	266		

TABLE 14.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	S 1 shell weight	Ligament to		Power of add. muscle			Power of ligament			Water temp.	Date
								Add. mus.	Point	Hung w.	W	W per. cm^2	Added w.	W′	W′ per. cm^2		
	gms.	c.m.	c.m.	gms.	gms.	cm^2	gms.	c.m.	c.m.	kgs.	kgs.	gms.	gms.	gms.	gms.	C°.	
1	7685	32.0	22.8	950	120.0	15.75	3000	10.0	18.5	42.0	80.70	5123				28	Jan. 20 1930
2	6000	32.0	23.5	890	105.0	19.00	2435	8.4	16.0	40.0	78.63	4138	900	4148	218	,,	,,
3	3935	28.0	17.0	300	52.0	10.50	1560	8.5	13.5	24.0	37.07	3530				,,	,,
4	3700	27.4	18.0	490	48.0	8.90	1460	7.5	14.0	17.5	34.12	3833				,,	,,
5	2700	25.5	16.5	450	45.0	7.00	868	7.6	14.0	16.0	30.29	4327	800	2343	334	,,	,,
6	2450	23.0	15.7	345	27.0	7.75	894	6.7	11.8	12.0	22.02	2841	600	1950	251	,,	,,
7	2350	22.0	15.5	280	35.0	5.75	970	7.3	12.0	10.0	17.40	3026				,,	,,
8	2250	23.0	15.0	258	45.0	7.00	840	5.0	10.0				550	1940	277	,,	,,
9	1850	23.0	15.0	270	36.0	5.50	700	6.0	10.0	12.0	20.70	3763				,,	,,
10	1800	21.5	13.7	240	22.0	5.00	600	7.2	11.4	8.5	13.90	2780				,,	,,
11	1750	22.8	14.4	210	20.0	5.00	650	6.0	11.0	8.0	15.31	3062	200	1016	203	,,	,,
12	1080	17.7	11.7	135	15.5	2.85	340	5.5	8.5	5.5	8.84	3101	400	958	336	,,	,,
13	1020	20.4	11.6	135	18.0	4.50	332	5.8	10.0	8.0	14.12	3137	200	675	150	,,	,,
Mean										17.0	31.09	3561	521	1861	384		

TABLE 15.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Power of add. muscle			Ligament power			Water temp.	Date
							Add. mus.	Point	Hung w.	W	W per. cm^2	Added w.	W′	W′ per. cm^2		
	grs.	c.m.	c.m.	grs.	grs.	cm^2	c.m.	c.m.	grs.	grs.	grs.	gms.	gms.	gms.	C°.	
1	10	4.2	2.5	2.0	9.5	0.75	2.2	3.0	3100	4220	5620	60	81	108	28	Jan. 6th 1930

TABLE 16.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. cm²	Power of ligament Added w.	Power of ligament W′	Power of ligament W′ per. cm²	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	cm²	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	15.0	7.8	2.1	6.0		0.85	4.5	4.5	1300	1300	1529				28	Dec. 27 1929
2	13.5	8.3	1.9	5.0		0.62	4.5	5.0	800	888	1432	100	111	179	,,	,,
3	12.5	7.4	1.9	5.0	0.4	0.90	4.2	4.2	1200	1257	1396				,,	,,
4	12.0	7.8	2.2	6.0	0.5	0.77	4.0	4.5	900	1012	1314	50	56	73	,,	,,
5	11.5	7.0	2.0	6.0		0.75	4.0	4.5	800	900	1200	70	78	104	,,	,,
6	11.0	6.8	2.0	5.0		0.60	4.0	4.5	800	900	1500				,,	,,
7	11.0	7.0	2.0	5.0		0.67	3.8	4.0	750	789	1177				,,	,,
8	10.5	7.0	2.0	5.2		0.50	4.0	5.0	700	875	1750	70	87	174	,,	,,
9	10.0	6.5	2.1	4.8		0.70	3.5	4.0	750	858	1225				,,	,,
10	8.0	6.5	1.8	4.0		0.60	3.0	3.5	600	700	1166	50	58	97	,,	,,
Mean	11.5			5.2		0.69			860	947.9	1369	68	78	125		

TABLE 17.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. cm²	Ligament Power Added w.	Ligament Power W′	Ligament Power W′ per. cm²	Water temp.	Date
	gms.	c.m.	c.m.	gms.		cm²	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	14.0	8.0	2.3	7.5		0.75	4.2	4.2	1000	1000	1333	50	50	66	28	Dec. 27 1929

10. *Hippoppus hippoppus* LINNÉ.

The experimental results obtained from 13 specimens which were collected at Palau are shown in Table 14.

The body weight of the 12 specimens ranged from 1020 gms. to 7685 gms. and the mean value was 3026 gms. The hung weight was 17000 gms., in average. The W calculated by the formula was 31090 gms., in mean. The power of the adductor muscle was estimated to be 3561 gms., in mean. The ratio of the body weight to the W was 1 : 10.2. The power of the ligament observed in seven tests was found to be 384 gms. The ratio of the power of the ligament to that of the adductor muscle was 1 : 9.3., in mean.

11. *Septifer bilocuralis* LINNÉ.

The experiment was made on only one specimen which was obtained from Palau Bay, and the results are shown in Table 15. A weight of 3100 gms. was hung so as to tear off the adductor muscle of this bivalve which weighed 10 gms. The power of the adductor muscle per sq. cm. of section area was calculated to be 5620 gms. The power of the ligament was measured to be 108 gms. The ratio of the body weight to the W was 1 : 422, and of the power of the ligament to the power of the adductor muscle was 1 : 55.

12. *Lithophaga gracilis* PHILIPPI.

The materials used were obtained from coral rock in Yap Bay. The results obtained from ten tests are given in Table 16.

The body weights ranged from 8.0 gms. to 15 gms. The weight needed to tear off the adductor muscle was 860 gms., in mean. The W calculated from the formula was 947.9 gms., in mean. The power of the adductor muscle per sq. cm. section area was determined to be 1369 gms. The ratio of the body weight to the W was 1 : 82.4. The power of the ligament per sq. cm. of section area was 125 gms. The ratio of the power of the ligament to that of the adductor muscle was 1 : 10.9.

13. *Lithophaga straminea* REEVE.

The present species much resembles *Lithophaga gracilis* in its form and was obtained from Yap Island. The results obtained are shown in Table 17.

The power of the adductor muscle was calculated to be 1333 gms. per sq. cm. of section area. The power of the ligament per sq. cm. of section area was estimated to be 66 gms. The ratio of the body

TABLE 18.

No.	Body weight	Length	Breadte	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Adductor muscle power			Ligament power			Water temp.	Date
							Add. mus.	Point	Hung w.	W	W per. cm^2	Added w.	W′	W′ per. cm^2		
	grs.	c.m.	c.m.	grs.	grs.	cm^2	c.m.	c.m.	grs.	grs.	grs.	grs.	grs.	grs.	C°.	
1	150	5.6	2.1	12.0	2.0	2.8	2.0	5.0	1200	3000	1071	25	62	22	28	Dec. 27th 1929

TABLE 19.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Power of add. muscle			Ligament power			Water temp.	Date
							Add. mus.	Point	Hung w.	W	W per. cm^2	Added w.	W′	W′ per. cm^2		
	grs.	c.m.	c.m.	grs.	grs.	cm^2	c.m.	c.m.	grs.	grs.	grs.	grs.	grs.	grs.	C°.	
1	10.0	3.8	2.1	2.0	0.3	0.55	0.5	2.0	1300	5200	9454				28	Dec. 28th 1929
2	7.0	3.3	2.0	1.7		0.45	0.5	1.6	1100	3520	7822	20	64	142	,,	,,
3	2.0	2.5	1.3	0.5		0.22	0.4	1.2	650	1950	8863	15	41	185	,,	,,
Mean	6.3			1.4		0.41			1016	3556	8646	17.5	52.5	163		

TABLE 20.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Power of add. muscle			Power of ligament			Water temp.	Date
							Add. mus.	Point	Hung w.	W	W per. cm^2	Added w.	W′	W′ per. cm^2		
	gms.	c.m.	c.m.	gms.	gms.	cm^2	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	17.5	6.4	3.3	8.5	0.6	1.5	1.0	3.0	1100	3300	2200	70	210	140	28	Dec. 21th 1929
2	15.0	5.4	3.2	4.5	0.4	1.5	0.8	3.1	950	3681	2454	50	193	128	,,	,,
3	8.5	4.5	2.5	3.0		0.4	0.5	2.3	250	1150	2875	35	161	402	,,	,,
Mean	13.6			5.3		1.1			766	2710	2509	52	188	223		

weight to the W was 1 : 71.4. The ratio of the power of the ligament to the power of the adductor muscle was 1 : 20.

14. *Coralliophaga coralliophaga* (GMELIN).

The material was collected at Yap and the results of the experiment are shown in Table 18.

The body weight was 15 gms. The weight used was 1200 gms. The W calculated by the formula was 3000 gms. The power of the adductor muscle was calculated to be 1071 gms., and that of the ligament was 22 gms. The ratio of the body weight to the W was 1 : 200. The ratio of the power of the ligament to the power of the adductor muscle was 1 : 48.6.

15. *Barbatia fusca* (SOLANDER).

The results obtained from three experiments which were made on the specimens collected at Palau are shown in Table 19.

As can be seen in the table, the power of the adductor muscle was calculated to be 8646 gms. per sq. cm. of section area. The power of the ligament was measured to be 163 gms. per sq. cm. of section area of the adductor muscle. The ratio of the body weight to the W was 1 : 566. The ratio of the power of the ligament to the power of the adductor muscle was 1 : 70.

16. "*Gari togata*" DESHAYES. (var.).

The experimental results obtained from three tests are given in Table 20. The materials were collected from the muddy bottom of the shore of Yap Island. The body weight was 13.6 gms., in mean. The weight used to tear off the adductor muscle was 766 gms., in average. The power of the adductor muscle was measured to be 2509 gms., and that of the ligament was 223 gms. per sq. cm. of section area of the adductor muscle. The ratio of the body weight to the W was 1 : 199. The ratio of the power of the ligament to that of the adductor muscle was 1 : 11.4.

17. *Anadara antiqua* (LINNÉ).

The results obtained from the experiments which were made on ten specimens collected at Yap Island are shown in Table 21.

The body weight of the specimens used ranged from 7.2 to 58.5 gms., showing a mean value of 18.9 gms. The hung weight was 1220 gms., in mean. The W calculated by the formula was 3466 gms. The power of the adductor muscle per sq. cm. of section area was 4942 gms.

TABLE 21.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to: Add. mus.	Ligament to: Point	Power of add. muscle: Hung w.	Power of add. muscle: W	Power of add. muscle: W per. $\overline{cm}^2$	Power of ligament: Added w.	Power of ligament: W′	Power of ligament: W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	58.5	6.0	4.0	10.7	2.1	1.45	0.8	3.3	2300	7590	4530				28	Dec. 22th 1929
2	23.7	4.1	2.9	3.7	1.0	0.85	0.9	2.5	1400	3880	4560	55	152	178	,,	20
3	23.0	4.2	3.0	4.3	0.9	0.85	1.0	2.5	900	2250	3230	70	175	206	,,	21
4	17.0	3.9	2.6	3.2	0.9	0.65	0.7	2.0	1400	4000	5230				,,	,,
5	15.0	3.8	2.3	2.5	0.7	0.60	0.7	1.8	1200	3080	5130	50	128	213	,,	20
6	13.5	3.5	2.3	2.6	0.8	0.65	0.7	1.8	1400	3600	5330				,,	21
7	12.2	3.5	2.3	2.5	0.7	0.55	0.6	1.9	1000	3100	5740	35	111	220	,,	20
8	10.0	3.2	2.2	2.6	0.7	0.60	0.7	2.0	950	2710	4510	40	114	190	,,	,,
9	9.4	3.0	2.0	1.8	0.4	0.40	0.6	1.6	1000	2660	5400				,,	21
10	7.2	2.7	2.0	1.7	0.4	0.30	0.6	1.6	650	1730	5760				,,	,,
Mean	18.95			3.6	0.86	0.68			1220	3466	4942	50	136	201		

TABLE 22.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to: Add. mus.	Ligament to: Point	Power of add. muscle: Hung w.	Power of add. muscle: W	Power of add. muscle: W per. $\overline{cm}^2$	Power of ligament: Added w.	Power of ligament: W′	Power of ligament: W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	75.0	6.5	5.5	20.0	2.5	1.90	2.1	5.8	2000	5523	2900	120	333	175.0	28	Dec. 29th 1929
2	65.0	6.2	5.3	17.0	1.7	1.30	2.0	6.0	2000	6000	4615	70	210	161.5	,,	,,
3	52.6	6.1	5.0	16.1	1.6	1.40	1.8	5.8	1500	4833	3452	110	354	252.8	,,	,,
4	45.0	5.5	5.0	10.0	1.2	1.10	1.5	5.0	1200	4000	3636	80	266	141.8	29	Dec. 28
5	38.0	5.2	4.5	9.9	1.5	1.00	1.5	4.6	800	2463	2463	100	307	307.0	,,	,,
6	36.0	5.1	4.6	10.5	1.7	1.00	1.3	4.5	1200	4154	4154				,,	,,
7	32.0	5.4	5.0	9.2	1.5	0.85	1.6	4.6	700	2012	2367	80	280	329.0	,,	,,
8	16.0	4.0	3.5	4.6	0.5	0.70	1.0	3.6	700	2520	3600	30	108	154.2	28	29
9	14.0	3.5	3.2	4.1	0.4	0.55	0.9	3.0	600	2000	3636	30	100	181.8	,,	,,
10	7.5	3.0	2.8	2.7	0.3	0.45	0.7	2.5	500	1785	3970	30	107	237.7	,,	,,
Mean	38.1			10.4	1.3	1.02			1120	3529	3479	83	229	215.6		

TABLE 23.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Hung weight	W	W per. $\overline{cm}^2$	Water temp.	Date
							Add. mus.	Point					
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	kgs.	kgs.	gms.	C°.	
1	550	9.2	8.0	18.0	7.2	7.15	3.2	7.0	48.0	105.0	14220	29	Dec. 21 1929
2	430	10.5	6.5	20.0	8.6	6.50	3.0	7.0	33.0	77.0	11810	,,	,,
3	430	11.2	8.6	25.0	8.5	7.50	4.0	8.0	33.0	75.0	10060	,,	4
4	390	9.0	7.2	18.0	6.0	5.65	2.8	6.6	35.0	81.2	10730	,,	,,
5	220	7.0	6.5	14.5	3.0	4.75	2.5	6.0	20.0	48.0	10100	,,	21
Mean	400			19.1	6.7	6.03			33.8	76.32	11381		

TABLE 24.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Added weight	W′	W′ per. $\overline{cm}^2$	Water temp.	Date
							Add. mus.	Point					
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	C°.	
1	870	11.0	10.5	30.0	9.0	12.00	3.5	7.5	30.0	60.0	5.0	29	Dec. 21 1929
2	605	10.0	9.5	26.0	7.5	8.50	3.0	6.0	50.0	100.0	12.0	,,	,,
3	440	11.0	7.5	19.0	4.0	6.60	3.0	6.0	50.0	100.0	15.1	,,	,,
Mean	638			25.0	6.8	9.00			43.3	86.6	10.7		

The ratio of the mean body weight to the W was 1 : 182. The power of the ligament per sq. cm. of section area of adductor muscle was 201 gms. The ratio of the power of the ligament to that of the adductor muscle was 1 : 24.5.

18. *Cardium subrugosum* SOWERBY.

The specimens were collected at both Yap and Palau islands. The results obtained from the experiments which were made on ten individuals are given in Table 22.

The body weight ranged between 7.5 gms. and 70 gms., showing a mean value of 38.1 gms. The W calculated by the formula was 1120 gms., in mean. The power of the adductor muscle per sq. cm. of section area was calculated to be 3529 gms. The power of the ligament per sq. cm. of section area of adductor muscle was 215.6 gms. The ratio of the body weight to the W was 1 : 16.1. The ratio of the power of the ligament to that of the adductor muscle was 1 : 92.8.

19. *Chama imbricata* BRODERIP.

The data obtained from the experiments made on five specimens which were collected at Yap Island are given in Table 23. The body weight ranged from 220 to 550 gms., showing a mean value of 400 gms. The weight needed to tear off the adductor muscle was 33800 gms., in mean. The W calculated by the formula was 76320 gms. The power of the adductor muscle measured to be 11381 gms. per sq. cm. of section area. The ratio of the body weight to the W was 1 : 190. The power of the ligament obtained from three tests was calculated to be 10.7 gms. The ratio of the power of the ligament to the adductor muscle was 1 : 1053.

20. *Venus (Antigona) puerpera* LINNÉ.

Of the specimens used four individuals were collected at Palau and two at Yap Island. The data obtained are given in Table 25. The body weight ranged from 30 gms. to 260 gms., showing an average of 105.6 gms. The hung weight was 8360 gms., in mean. The W calculated by the formula was 20750 gms. The power of the adductor muscle per sq. cm. of section area was 8871 gms. The ratio of the mean body weight to the W was 1 : 196. The power of the ligament per sq. cm. of section area of the adductor muscle was calculated to be 483 gms. The ratio of the power of the ligament to that of the adductor muscle was 1 : 18.3.

TABLE 25.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. $\overline{cm}^2$	Power of ligament Added w.	Power of ligament W′	Power of ligament W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	kgs.	kgs.	gms.	gms.	gms.	gms.	C°.	
1	260	7.6	9.0	59.0	7.5	4.90	2.5	6.0	15.0	36.00	7367				29	Dec. 20 1929
2	139	6.0	6.7	23.0	4.0	2.85	2.3	5.5	10.0	23.90	8385				,,	Jan. 24 1930
3	120	6.0	6.8	20.0	3.8	2.95	2.2	5.5	10.0	25.00	8475				,,	,,
4	50	4.7	4.3	8.0	1.2	1.50	1.4	4.0	5.5	15.71	10473	400	1142	564	,,	,,
5	44	4.4	4.8	8.0	1.2	1.40	1.7	4.0	6.2	14.58	10414	240	761	403	,,	20
6	30	4.3	3.9	7.5	1.2	1.15	1.2	3.2	3.5	9.33	8112				,,	24
	105.6			20.9	3.2	2.45			8.36	20.75	8871	320	951	483		

TABLE 26.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. $\overline{cm}^2$	Power of ligament Added w.	Power of ligament W′	Power of ligament W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	25.5	4.0	3.3	1.9	0.5	0.80	1.2	3.3	2800	7700	9625	90	247	309	27	Jan. 9 1930
2	24.5	4.2	3.4	2.0	0.3	0.80	1.2	3.3	3000	8250	10312	80	220	275	,,	
3	21.5	3.9	3.1	2.3	0.4	0.75	1.1	2.8	2200	5400	7200				,,	,,
4	20.0	3.8	3.0	2.0	0.3	0.80	1.1	2.7	2400	5890	7362	50	122	153	,,	,,
5	17.0	3.6	3.0	1.7	0.3	0.65	1.0	2.7	2400	6480	9969	30	81	121	,,	,,
6	16.0	3.5	2.9	1.9		0.60	0.8	2.7	2200	7410	11092	40	135	208	,,	,,
7	15.0	3.5	2.8	1.7		0.70	0.8	2.8	2100	5350	7624				,,	,,
8	13.5	3.5	2.8	1.6		0.70	0.9	2.6	2600	7510	10742				,,	,,
9	13.5	3.4	2.8	1.4		0.60	0.8	2.6	1300	4470	7450				,,	,,
10	12.0	3.3	2.7	1.6		0.50	0.8	2.5	1700	5310	10620				,,	,,
Mean	17.8			1.8		0.69			2270	6377	9201	58	151	201		

TABLE 27.

No.	Body weight	Length	Breadth	Tissue weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Hung weight	W	W per. cm^2	Water temp.	Date
	gms.	c.m.	c.m.	gms.	cm^2	c.m.	c.m.	gms.	gms.	gms.	C°.	
1	7.5	2.9	2.2	1.6	0.40	0.8	2.0	1300	3250	8122	27	Dec. 20 1929
2	7.0	2.8	2.1	2.0	0.41	0.7	1.9	1300	3528	8604	,,	,,
3	6.6	2.7	2.0	1.5	0.38	0.7	1.8	1200	3085	8118	,,	,,
4	6.0	3.0	2.2	2.2	0.40	0.7	1.9	1300	3527	8817	,,	,,
5	5.4	2.7	2.1	1.5	0.35	0.6	1.8	1000	3000	8571	,,	,,
6	5.3	2.7	1.9	1.4	0.40	0.6	1.8	1100	3300	8250	,,	,,
7	5.1	2.6	2.0	1.3	0.35	0.7	1.8	1200	3085	8314	,,	,,
8	4.9	2.7	2.0	1.6	0.28	0.6	1.7	900	2550	9107	,,	,,
9	4.9	2.6	1.9	1.2	0.37	0.6	1.7	1250	3541	9570	,,	,,
10	4.8	2.5	1.9	1.0	0.30	0.6	1.6	950	2533	8443	,,	,,
Mean	5.8			1.5	0.36			1150	3139	8592		

TABLE 28.

No.	Body weight	Length	Breadth	Tissue weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Added weight	W′	W′ per. cm^2	Water temp.	Date
	gms.	c.m.	c.m.	gms.	cm^2	c.m	c.m.	gms.	gms.	gms.	C°.	
1	8.7	2.9	2.1	1.7	0.45	0.7	1.8	100	257	571	27	Dec. 20 1929
2	6.5	2.8	1.9	1.6	0.30	0.7	1.8	80	205	683	,,	,,
3	5.2	2.7	2.0	1.7	0.40	0.6	1.7	60	170	425	,,	,,
4	4.3	2.7	1.9	1.2	0.30	0.7	1.7	80	194	646	,,	,,
5	4.0	2.6	2.0	0.9	0.25	0.5	1.3	70	185	740	,,	,,
Mean	5.74			1.66	0.34			78	202	613		

21. *Gafrarium gibbium* (LAMARCK).

The results of the experiment, using ten individuals collected at Yap Island, are shown in Table 26.

The body weight ranged between 12 gms. and 25.5 gms., showing a mean value of 17.8 gms. The hung weight was 2270 gms. The W colculated by the formula was 6377 gms. The power of the adductor muscle was estimated to be 9201 gms. per sq. cm. of section area. The ratio of the mean body weight to the adductor muscle was 1 : 358. The power of the ligament per sq. cm. of section area of adductor muscle was 201 gms. The ratio of the power of the ligament to that of the adductor muscle was 1 : 45.7.

22. *Gafrarium pectinatum* (LINNÉ).

The materials were collected at Palau Island. The power of the muscle is given in Table 27. The body weight ranged from 4.8 to 7,5 gms., showing an average of 5.8 gms. The weight needed to tear off the adductor muscle was 1150 gms, in average. The W calculated by the formula was 3139 gms., in mean. The power of the adductor muscle per sq. cm. of section area was measured to be 8592 gms. The ratio of the mean body weight to the W was 1 : 545. The power of the ligament, calculated from five tests shown in Table 28, was found to be 613 gms. The ratio of the power of the ligament to that of the adductor muscle was 1 : 14.

22. *Paphia* (*Tapes*) *litterata* (LINNÉ).

The results obtained from experiments carried out by using two specimens which were collected at Yap Island are shown in Table 29.

The power of the adductor muscle per sq. cm. of section area was calculated to be 6428 gms., and the power of the ligament was found to be 602 gms. The ratio of the body weight to the W was 1 : 407. The ratio of the power of the ligament to the adductor muscle was 1 : 10.6.

24. *Paphia* (*Ruditapes*) *variegata* (SOWERBY).

The specimens were collected at Yap Island. The power of the adductor muscle, observed in 13 tests, is shown in Table 30. The body weight ranged between 2.7 gms. and 5.7 gms., showing an average value of 4.43 gms. The hung weight was 703 gms., in mean. The W calculated by the formula was 2206 gms. The power of the adductor muscle per sq. cm. of section area was measured to be

TABLE 29.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to: Add. mus.	Ligament to: Point	Power of add. muscle: Hung w.	Power of add. muscle: W	Power of add. muscle: W per. $\overline{cm}^2$	Power of ligament: Added w.	Power of ligament: W′	Power of ligament: W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	22.0	6.4	4.0	7.5	0.7	1.15	1.1	3.5	2600	8272	7106	220	700	608	28	Dec. 16 1929
2	14.0	5.2	3.3	4.6	0.5	0.85	0.8	3.2	1600	6400	5750	130	508	597	,,	,,
Mean	18.0			6.1		1.00			2100	7335	6428	175	604	602		

TABLE 30.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to: Add. mus.	Ligament to: Point	Hung weight	W	W per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	C°.	
1	5.7	3.0	2.1	1.3		0.30	0.6	1.9	650	2583	8610	28	Dec. 25 1929
2	5.7	3.0	1.9	1.5	0.1	0.30	0.6	1.8	800	2400	8000	,,	,,
3	5.5	2.9	2.0	1.3		0.27	0.6	1.8	800	2400	8888	,,	,,
4	5.0	3.0	2.0	1.2		0.31	0.6	1.8	850	2555	8451	,,	,,
5	4.7	2.9	1.9	1.1		0.32	0.6	1.8	900	2700	8437	,,	,,
6	4.7	2.9	1.8	1.1		0.32	0.6	1.7	1000	2833	8853	,,	,,
7	4.7	2.7	1.8	0.9		0.26	0.6	1.8	700	2100	8076	,,	,,
8	4.6	2.6	1.9	1.7		0.22	0.6	1.7	650	1841	8368	27	Dec. 20 1929
9	4.3	2.8	1.9	0.8		0.23	0.6	1.9	600	1900	8260	28	25
10	4.0	2.9	1.9	1.0	0.1	0.26	0.5	1.7	750	2550	9808	,,	,,
11	3.4	2.6	1.7	1.5		0.18	0.5	1.4	450	1325	7341	27	20
12	2.7	2.6	1.6	0.9		0.18	0.4	1.4	500	1750	9722	,,	,,
13	2.7	2.3	1.6	1.0		0.18	0.5	1.4	500	1750	9722	,,	,,
Mean	4.43			1.17		0.27			703	2206	8655		

Table 31.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Hung weight	W′	W′ per. cm^2	Water temp.	Date
	grs.	c.m.	c.m	grs.		cm^2	c.m.	c.m.	grs.	grs.	gms.	C°.	
1	4.0	2.7	2.0	1.3		0.20	0.5	1.6	75	240	1200	27	Dec. 20th 1929
2	3.5	2.6	1.5	0.9		0.18	0.5	1.4	70	196	1088	„	„
3	2.5	2.5	1.7	0.9		0.16	0.5	1.5	60	180	1125	„	„
4	2.2	2.3	1.6	0.6		0.15	0.5	1.4	60	168	1120	„	„
5	1.6	1.9	1.3	0.9		0.09	0.4	1.1	40	110	1220	„	„
Mean	2.76			0.92		0.156			60.1	178	1151		

Table 32.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Muscle strength			Power of add. muscle			Water temp.	Date
							Add. mus.	Point	Hung w.	W	W per. cm^2	Add. mus.	W′	W′ per. cm^2		
	grs.	c.m.	c.m.	grs.	grs.	cm^2	c.m.	c.m.	grs.	grs.	grs.	grs.	grs.	grs.	C°.	
1	12.5	4.3	3.1	3.1	0.5	0.9	1.1	3.0	2300	6270	6960	50	136	151	28	Jan. 6th 1930
2	13.5	4.4	3.4	2.2	0.6	1.1	1.2	3.0	2500	6500	5910	45	135	122	„	„
Mean	13.0			2.6	0.55	1.0			2400	6380	6435	48	136	137		

TABLE 33.

No.	Body weight	Length	Breadth	Tissue weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Hung weight	W	W per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	C°.	
1	5.5	2.8	2.1	1.1	0.17	0.7	1.8	700	1657	9747	30	Nov. 24 1929
2	5.4	2.8	2.1	1.2	0.18	0.8	1.9	800	1900	10555	,,	,,
3	5.3	2.7	2.0	1.0	0.23	0.8	1.8	900	2025	8804	,,	,,
4	5.3	2.7	2.1	1.2	0.22	0.7	1.8	1000	2571	11686	,,	,,
5	5.2	2.5	2.0	1.2	0.18	0.7	1.8	900	2314	12888	,,	,,
6	5.1	2.7	2.1	1.2	0.19	0.7	1.7	900	2185	12022	,,	,,
7	4.8	2.8	2.0	1.0	0.23	0.7	1.8	800	2028	8815	,,	,,
8	4.7	2.7	2.0	1.1	0.25	0.8	1.9	1000	2375	9500	,,	,,
9	4.3	2.5	2.0	1.0	0.20	0.7	1.7	1000	2328	12140	,,	,,
10	4.2	2.5	1.9	1.0	0.15	0.7	1.6	900	2057	13714	,,	,,
Mean	4.98			1.1	0.20			890	2154	10987		

TABLE 34.

No.	Body weight	Length	Breadth	Tissue weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Added weight	W′	W′ per. $\overline{cm}^2$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	C°.	
1	5.5	2.9	2.3	1.1	0.16	0.9	2.1	40	93.0	581	30	Nov. 24 1929
2	5.0	2.8	2.2	1.2	0.21	0.9	2.0	40	88.8	423	,,	,,
3	4.5	2.8	2.2		0.20	0.8	1.8	45	101.0	505	,,	,,
4	4.5	2.8	2.1	1.0	0.21	0.8	1.8	55	123.0	585	,,	,,
5	4.3	2.6	2.0	1.1	0.18	0.8	1.9	40	95.0	522	,,	,,
6	4.1	2.5	2.0		0.20	0.8	1.8	30	67.5	337	,,	,,
7	4.0	2.8	2.1	1.0	0.18	0.8	1.9	40	95.0	527	,,	,,
8	4.0	2.6	2.0		0.16	0.7	1.7	45	109.0	681	,,	,,
9	4.0	2.6	2.0		0.17	0.8	1.8	40	90.0	529	,,	,,
10	4.0	2.5	1.9		0.15	0.7	1.7	40	97.0	646	,,	,,
Mean	4.4				0.18			43	96.9	543.6		

8655 gms. The ratio of the mean body weight to the mean W was 1 : 297. The power of the ligament, observed in five tests, is shown in Table 31.

From this table one will notice that the power of the ligament was measured to be 1151 gms. The ratio of the ligament to the adductor muscle was 1 : 7.5.

25. *Marcia (Hemitapes) striata* (GMELIN).

The specimens used were collected in the muddy bottom of the sea-shore, covered with the shaggy mangrove bushes at Yap Island. The results obtained from the experiment made on two specimens are listed in Table 32.

The body weight was 13 gms., in mean. The hung weight was 2400 gms., in average. The W calculated by the formula was 6380 gms. The power of the adductor muscle per sq. cm. of section area was determined to be 6435 gms. The ratio of the body weight to the W was 1 : 490. The power of the ligament per sq. cm. of section area of adductor muscle was measured to be 137 gms. The ratio of the power of the ligament to the power of the adductor muscle was 1 : 46.

26. *Atactodea striata* GMELIN.

The materials were collected at Yap Island. The power of the adductor muscle, determined in ten experiments, is shown in Table 33.

The body weight ranged from 4.2 to 5.5 gms., showing a mean value of 4.98 gms. The weight needed in tearing off the adductor muscle instantly after loading was 980 gms., in mean. The W acting on the adductor muscle was calculated to be 2154 gms., in mean. The power of the adductor muscle per sq. cm. of section area was 10987 gms. The ratio of the mean body weight to the W was 1 : 432. The power of the ligament, observed in this experiment made on 10 specimens, is given in Table 34. The body weight was 4.4 gms., in mean. The weight used to close the shells entirely was 43 gms., in mean. The W acting on the adductor muscle was 96.9 gms. The power of the ligament was 543.6 gms. The ratio of the power of the ligament to the power of the adductor muscle was found to be 1 : 20.2.

27. *Asaphis deflorata* (LINNÉ).

The data obtained from the experiments made on ten specimens which were collected at Yap Island are shown in Table 35.

TABLE 35.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. $\overline{cm^2}$	Power of ligament Added w.	Power of ligament W′	Power of ligament W′ per. $\overline{cm^2}$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm^2}$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	89.0	7.7	5.5	23.0	2.5	3.35	1.9	4.8	6300	15915	4750	450	1363	407	29	Feb. 13 1930
2	59.0	6.7	5.0	17.0	0.7	2.10	1.8	4.5	3800	9500	4523	400	844	401	,,	,,
3	52.0	7.3	4.9	15.0	0.8	2.70	1.7	4.5	4800	12588	4659	300	794	293	,,	,,
4	48.0	6.1	4.5	14.0	0.9	2.35	1.6	4.1	5000	12812	5452	350	896	381	,,	,,
5	45.0	6.4	4.5	13.0	0.6	2.25	1.6	4.0	3800	9500	4222				,,	,,
6	42.0	6.1	4.2	12.0	0.6	1.45	1.2	3.7	2500	7708	5315	320	986	680	,,	,,
7	43.0	6.0	4.2	12.0	0.8	1.65	1.3	3.8	2500	7846	4755	250	730	442	,,	,,
8	41.0	6.3	4.4	12.0	0.8	1.90	1.5	4.0	4300	11466	6034	400	1070	563	,,	,,
9	40.0	6.7	4.5	13.0	0.7	1.90	1.5	4.0	3800	10133	5333	300	800	421	,,	,,
10	30.0	5.8	4.1	8.2	0.8	1.40	1.3	3.7	2500	7115	5082	250	711	578	,,	,,
Mean	53.0			13.9	0.8	2.06			3940	10458	5467	335	910	463		

TABLE 36.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to Add. mus.	Ligament to Point	Power of add. muscle Hung w.	Power of add. muscle W	Power of add. muscle W per. $\overline{cm^2}$	Power of ligament Added w.	Power of ligament W′	Power of ligament W′ per. $\overline{cm^2}$	Water temp.	Date
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm^2}$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	22.0	5.4	4.0	5.3	1.0	1.50	1.5	3.7	2400	5920	3949	200	460	307	27	Jan. 7 1930
2	17.0	5.0	3.7	4.7	0.6	1.20	1.4	3.6	1400	3600	3000	90	303	253	,,	,,
3	17.0	5.0	4.0	4.3	0.7	1.25	1.5	3.5	2300	4700	3760	200	466	372	,,	,,
4	16.0	5.0	3.5	4.6	0.8	1.10	1.5	3.4	1900	4320	3909				,,	,,
5	16.0	5.3	4.0	4.5	0.6	1.50	1.5	3.6	2000	4600	3106	120	288	192	,,	,,
6	16.0	5.2	3.8	4.5	0.6	1.20	1.4	3.5	1800	3780	3150	160	400	333	,,	,,
7	15.5	4.9	3.7	4.2	0.6	1.60	1.4	3.6	2300	5480	3425	130	434	271	,,	,,
8	15.0	5.0	3.5	4.0	0.7	1.40	1.5	3.7	2200	5420	3871	150	370	264	,,	,,
9	11.0	4.5	3.2	4.0	0.5	1.10	1.3	3.1	1900	4530	4118	120	286	260	,,	,,
10	10.5	4.4	3.3	3.4	0.5	0.97	1.3	3.0	1500	3460	3567	100	231	238	,,	,,
Mean	15.6			4.4	0.66	1.28			1970	4585	3585		359	276.5		

TABLE 37.

No.	Body weight	Length	Breadth	Tissue weight	Weight of add. mus.	Area of add. mus.	Ligament to		Hung weight	W	W per. $\overline{cm}^2$	Water temp.	Date
							Add. mus.	Point					
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	C°.	
1	15.5	4.3	3.3	4.0		0.80	1.1	3.0	1200	3630	4537	28	Jan. 6th 1930
2	15.0	4.4	3.4	3.6		0.60	1.2	3.2	1400	4480	7460	,,	,,
3	14.0	3.7	3.0	2.5		0.75	1.0	2.6	1200	3120	4160	,,	,,
4	11.0	3.8	3.2	3.1	0.5	0.60	1.0	2.7	1100	2700	4500	,,	,,
5	11.0	3.8	3.3	3.2		0.75	0.9	2.8	1000	3110	4146	,,	,,
6	9.0	3.2	2.8	2.5		0.50	0.9	2.5	1200	3220	6440	,,	,,
7	8.0	3.2	2.6	2.0		0.35	0.9	2.4	900	2400	6857	,,	,,
8	8.0	3.5	2.8	2.8		0.40	1.0	2.6	1100	2860	7150	,,	,,
9	8.0	3.6	2.8	2.0	0.3	0.50	0.9	2.8	1200	3620	7240	,,	,,
10	7.0	3.0	2.5	1.8	0.15	0.35	0.8	2.2	900	2470	7057	,,	,,
Mean	10.7			2.8		0.56			1120	3161	5955		

TABLE 38.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Added weight	W′	W′ per. $\overline{cm}^2$	Water temp.	Date
							Add. mus.	Point					
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m	gms.	gms.	gms.	C°.	
1	16.0	4.6	3.5	3.8	0.40	0.95	1.1	3.1	65	253.0	255	28	Jan. 6th 1930
2	14.0	4.5	3.6	3.5	0.50	1.00	1.3	3.3	45	148.5	148	,,	,,
3	8.5	3.8	3.2	2.0	0.40	0.85	1.0	2.9	30	87.0	102	,,	,,
4	7.0	3.0	2.5	1.8	0.15	0.35	0.8	2.2	20	55.0	137	,,	,,
5	7.0	3.0	2.5	1.8		0.55	0.8	2.3	40	115.0	209	,,	,,
Mean	10.5			2.6		0.74			40	131.6	170		

The body weights varied from 30 gms. to 89 gms., showing a mean value of 53 gms. The hung weight was 3940 gms., in mean. The large W calculated by the formula was 10458 gms. The power of the adductor muscle per sq. cm. of section area was 5467 gms. The ratio of the body weight to the W was 1 : 196. The power of the ligament per sq. cm. of section area of adductor muscle was measured to be 463 gms. The ratio of the ligament to the adductor muscle was 1 : 11.8.

28. *Tellina rugosa* BORN.

The results were obtained from experiments made on ten specimens which were collected at Yap Island, and are tabulated in Table 36.

The body weight varied from 10.5 to 22 gms., showing a mean value of 15.6 gms. The hung weight was 1970 gms. The W calculated by the formula was 4585 gms. The power of the adductor muscle per sq. cm. of section area was found to be 3585 gms. The ratio of the mean body weight to the W was 1 : 293. The power of the ligament was measured to be 276,5 gms. The ration of the power of the ligament to the power of the adductor muscle was 1 : 12.9.

29. *Pitar crocea* REEVE.

Ten specimens were collected from the muddy bottom of the beach covered with mangrove bushes at Yap Island. The results are given in Table 37.

The body weight ranged between 7.0 gms. and 15.5 gms., showing a mean value of 10.7 gms. The hung weight was 1120 gms. The W calculated by the formula was 3161 gms., in average. The power of the adductor muscle per sq. cm. of section area was measured to be 5955 gms. The ratio of the body weight to the W was 1 : 296. The power of the ligament, obtained from experiments made on five specimens, is shown in Table 38.

The average body weight was 10.5 gms. The weight needed to close the shells completely was 40 gms., in mean. The power of the ligament per sq. cm. of section area of adductor muscle was 170 gms. The ratio of the power of the ligament to the power of the adductor muscle was 1 : 25.

30. *Lucina phillippina* REEVE.

The data obtained from experiments made on ten specimens, collected from the muddy botton of the beach covered with shaggy

TABLE 39.

No.	Body weight	Length	Breadth	Tissue weight	Add. mus. weight	Area of add. mus.	Ligament to		Power of add. muscle			Power of ligament			Water temp.	Date
							Add. mus.	Point	Hung w.	W	W per. cm.	Added w.	W′	W′ per. $\overline{cm}^2$		
	gms.	c.m.	c.m.	gms.	gms.	$\overline{cm}^2$	c.m.	c.m.	gms.	gms.	gms.	gms.	gms.	gms.	C°.	
1	62.0	6.0	6.8	24.7	2.2	2.40	2.0	5.7	2000	5000	2375	130	371	154	28	Dec. 22 1929
2	52.0	5.8	6.5	24.0	1.5	1.90	1.6	5.3	1200	3970	2073				,,	,, 21 ,,
3	50.0	5.5	6.0	24.0	2.1	2.30	1.8	5.3	2200	6477	2816	130	282	166	,,	,, 22 ,,
4	48.0	5.6	6.1	24.0	1.7	1.95	1.6	5.4	1700	5737	2942	130	437	224	,,	,, ,, ,,
5	48.0	5.5	6.0	24.0	2.1	2.15	1.9	5.2	1950	5278	2454				,,	,, ,, ,,
6	47.0	5.5	6.0	23.5	1.6	2.10	1.6	5.0	1450	4400	2095	150	468	223	,,	,, 21 ,,
7	42.0	5.5	5.5	18.0	1.0	2.10	1.5	5.2	1400	4853	2310				,,	,, ,, ,,
8	40.0	5.1	5.7	17.0	1.9	1.95	1.5	4.9	1700	5553	2847	100	327	116	,,	,, 22 ,,
9	34.0	5.5	5.6	18.5	1.2	1.50	1.5	5.0	1200	4000	2666	120	400	266	,,	,, 21 ,,
10	31.0	5.0	5.5	10.5	1.7	1.50	1.4	4.6	1400	4600	3066				,,	,, 22 ,,
Mean	45.4			20.8	1.7	1.98			1620	5057	2664	127	398	192		

mangrove bushes at Yap Island, are shown in Table 39. The body weight varied from 31 gms. to 62 gms., showing a mean value of 45.4 gms. The average weight needed to tear off the adductor muscle was 1620 gms. The W calculated by the formula was 5057 gms. The power of the adductor muscle per sq. cm. of section area was 2664 gms. The ratio of the mean body weight to the W was 1 : 111.3. The power of the ligament per sq. cm. of section area of adductor muscle was measured to be 192 gms. The ratio between the power of the ligament and the power of the adductor muscle was found to be 1 : 13.8.

CONCLUSION AND DISCUSSION.

The power of the adductor muscle and of the ligament, observed on thirty species, are given in Table 40.

TABLE 40.

Species	Adductor mus. power		Ligament power		Body weight: W	Lig. power: add. m.p.
	Tests	Per. sq. c.m. section	Tests	Per. sq. c.m. of mus.		
		gms.		gms.		
Chama imbricata BRODERIP.	5	11381	3	10.7	1:190.0	1:1053
Atactodea striata GMELIN.	10	10987	10	543.6	1:432.0	1:20.2
Ostrea dendata KUSTER.	10	9587	10	361.0	1: 79.2	1:26.5
Gafrarium gibbium (LAMARCK).	10	9201	5	201.0	1:358.0	1:45.7
Venus (*Antigona*) *puerpera* LINNÉ.	6	8871	2	483.0	1:196.0	1:18.3
Pinctada margaritifera LINNÉ.	11	8690	1	180.0	1:135.0	1:48.0
Paphia (*Ruditapes*) *variegata* (SOWERBY).	13	8655	5	1151.0	1:497.0	1: 7.5
Barbatia fusca (SOLANDER).	3	8646	2	163.0	1:566.0	1:70.0
Gafrarium pectinatum (LINNÉ).	10	8592	5	613.0	1:545.0	1:14.0
Tridacna crocea LAMARCK.	3	7530	3	266.0	1: 86.0	1:28.3
Pteria macroptera LAMARCK.	2	7049	2	99.0	1:124.0	1:71.0
Marcia (*Hemitapes*) *striata* (GMELIN).	2	6435	2	137.0	1:490.0	1:46.0
Paphia (*Tapes*) *litterata* (LINNÉ).	2	6428	2	602.0	1:407.0	1:10.6
Pitar crocea REEVE. (var.).	10	5955	5	296.0	1:170.0	1:25.0
Septifer bilocularis LINNÉ.	1	5620	1	108.0	1:422.0	1:55.0
Asaphis deflorata (LINNÉ).	10	5467	9	463.0	1:196.0	1:11.8
Tridacna elongata LAMARCK.	9	5294	4	196.0	1: 27.2	1:27.0

Species	Adductor mus. power: Tests	Adductor mus. power: Per. sq. c.m. section	Ligament power: Tests	Ligament power: Per. sq. c.m. of mus.	Body weight: W	Lig. power: add. m.p.
		gms.		gms.		
Anadara antiqua (LINNÉ)	10	4942	5	201.0	1:182.0	1:24.5
Tridacna squamosa LAMARCK.	8	4023	4	239.0	1: 14.3	1:16 8
Spondylus spectrum (?) REEVE.	10	3642	5	57.2	1: 30.3	1:65.0
Tellina rugosa BORN.	10	3585	9	276.5	1:293.0	1:12.9
Hippoppus hippoppus LINNÉ.	13	3561	7	384.0	1: 10.2	1: 9.2
Cardium subrugosum SOWERBY.	10	3479	9	215.6	1: 92.8	1:16.1
Lima (Ctenoides) tenera SOWERBY.	10	3268	10	127.0	1:332.0	1:33.0
Lucina philippiana REEVE.	10	2664	6	192.0	1:111.3	1:13.8
"*Gari togata*" DESHAYES (var.).	3	2509	3	223.0	1:199.0	1:11.4
Chlamys radura (LINNÉ).	2	1718	1	75.0	1:305.0	1:22.0
Lithophaga gracilis PHILIPPI.	10	1369	5	125.0	1: 82.4	1:10.9
Lithophaga straminea REEVE.	1	1333	1	66.0	1: 71.4	1:20.0
Coralliophaga coralliophaga (GMELIN).	1	1071	1	22.0	1:200.0	1:48.6

The power of the adductor muscle.—One will notice from the above table that the power of the adductor muscle differs according to the species as well as to individuals. The power of the *Coralliophaga* was 1071 gms. per sq. cm., while in the case of *Chama* it was measured to be 11381 gms. Consequently, the latter species showed about ten times as much power as the former one. PLATEAU (1884) studied fifteen species, stating that the power of *Pecten apercularis* showed a minimum value of 530 gms. in contrast to a maximum power of 12431 gms., which was found in *Venus vercosa*. The present author (1929) examined seven species of common bivalves, and found that the minimum power of 445 gms. was found in *Pecten yesoensis*, while the maximum power of 7880 gms. was found in *Ostrea circumpicta*. For convenience of comparison, the power which was found in various species by the present writer and other authors has been listed in the following table.

Venus vercosa.	12431 gms.	(PLATEAU)
V. (Antigona) puerpera.	8871 „	(TAMURA)
Gafrarium gibbium	9201 „	(TAMURA)
G. pectinatum.	8592 „	(TAMURA)

Ostrea dendata.	9587 gms.	(TAMURA)
Ostrea circumpicta.	7888 „	(TAMURA)
O. hippoppus.	6365 „	(PLATEAU)
O. edulis.	3786 „	(PLATEAU)
Tridacna crocea.	7530 „	(TAMURA)
T. elongata.	5294 „	(TAMURA)
T. elongata.	4917–7220 gms.	(VAILLANT)
T. squamosa.	4023 „	(TAMURA)
Cardium edule.	2856 „	(PLATEAU)
C. subrugosum.	3779 „	(TAMURA)
Tellina solidula.	3667 „	(PLATEAU)
T. rugosa.	3585 „	(TAMURA)
Lithophaga gracilis.	1369 „	(TAMURA)
L. straminea.	1333 „	(TAMURA)
Pecten maximus.	3786 „	(PLATEAU)
P. apercularis.	530 „	(PLATEAU)
P. yessoensis.	445 „	(TAMURA)
Chlamys senatorius.	1272 „	(TAMURA)
C. radula.	530 „	(TAMURA)

Looking through the above table, one will notice the fact that the power of the adductor muscle in the same genera is closely similar, although differences among individuals are sometimes remarkable.

Individual variations upon the power of the adductor muscles.

Ostrea dendata.

10 Specimens.	8000–11360 gms.	9587 gms., in mean.

Anadara antiqua.

10 Specimens.	3230–5760 gms.	4942 gms., in mean.

Lithophaga gracilis.

10 Specimens.	1160–1750 gms.	1369 gms., in mean.

The reason for such differences may surely be attributed to the size, activity and other conditions of the animal. In this connection I (1929) once made experiment on *Ostrea circumpicta* and found that the power of the adductor muscle per sq. cm. of section area of the oyster differs according to the dimensions of the animal. Therefore it follows that the larger the animal, the stronger the power, and vice versa. Moreover, I found that when the oyster was narcotized with menthol or chroloform the power of the adductor muscle was markedly

diminished. De Buison (1927) studied the influence of acid and alkali upon the muscle of *Anodonta* and found that it becomes stronger by HCl, and weaker by $NaHCO_3$.

The power of the ligament. — The ligament of the Lamellibranchs acts so as to open the shells in opposition to the closing power of the adductor muscle. Table 40 shows us that the power of the ligament differs according to the species, as in the case of the adductor muscle. In these experiments the maximum power of the ligament per sq. cm. of section area of adductor muscle of *Paphia* was calculated to be 1151 gms., while it was as small as 10.7 gms. in *Chama*, and 22 gms. in *Coralliophaga*. Plateau (1884) tested the power of the ligament of fourteen species, and stated that Mytilus edulis showed the maximum power of 1051 gms., and that *Pecten apercularis* showed the minimum power of 30 gms. From the experiments made on seven species of bivalves at Asamushi, I found that this power was 347 gms. in *Ostrea circumpicta*, and 14 gms. in *Pecten yessoensis*. According to the studies just referred to, the difference in the power of the ligament due to species is as follows:

Mytilus edulis.	1051 gms.	(Plateau)
M. crassitesta.	416 „	(Tamura)
Venus vercosa.	500 „	(Plateau)
V. (Antigona) puerpera.	483 „	(Tamura)
Ostrea dendata.	361 „	(Tamura)
O. circumpicta.	347 „	(Tamura)
O. edulis.	333.8 „	(Plateau)
Pecten maximus.	350 „	(Plateau)
P. apercularis.	30 „	(Plateau)
P. yessoensis.	14 „	(Tamura)
Chlamys radula.	75 „	(Tamura)
C. senatorius nobilis.	40 „	(Tamura)

As will be seen in the above table, the power of the ligament per sq. cm. of section area of adductor muscle is similar within each genus.

The relation between the power of the ligament and of the adductor muscle. — As just mentioned, the ligament of bivalves has considerable power, and this power is always acting so as to open the shells. Therefore; the adductor muscle of Lamellibranchs is perpetually forced to resist the power of the ligament. In connection with this point,

interesting accounts have thus far been given. COUTANCE (1878) first found that the adductor muscle of *Pecten* consists of two distinct parts, one of them large and transparent and the other small and opaque. Thereafter, PLATEAU (1884) estimated the power of the muscle of the oysters, *Pecten* and *Anodonta*, and indicated that the small opaque part was stronger in power than the large transparent part. MARCEAU (1905), who examined the resisting power of the adductor muscle of *Pecten maximum* and *Mactra glauca*, observed that the adductor muscle of Acephales consists of two kinds of muscle fibres. The same author demonstrated the existence of a difference in the the functions of these two parts. On the other hand, PAWLOW (1885) indicated that the tonus contraction of the adductor muscle of *Anodonta* is not induced by the inhibition of the impluse conducted from the visceral nerve. His statment was based on the fact that even when the visceral ganglion was cut off the tonus might be continued normally. UEXKÜLL (1912) studied the function of the adductor muscle of *Pecten* and found that the large adductor muscle, which he called 'Bewegung Muskel' (motor muscle), makes a quick contracting movement of the shells, while the smaller one, which he called 'Sperrung Muskel' (catch muscle), holds any tonic condition which is brought about by the contraction of the motor muscle. BAYLISS (1920) gave a diagramatic illustration of the catch mechanism of the small muscle in his text book. He also recognized two kinds of muscles in the adductor muscle, calling the larger one motor muscle and the smaller one catch muscle after UEXKÜLL. According to BAYLISS, the motor muscle consists of cros-striated fibres, and the catch muscle (that is, the opaque part) consists of smooth fibres. PARNAS (1910) made an experiment in which he loaded a weight of 3000 gms. on an *Anodonta* whose adductor muscle was 0.3 sq. cm. section area. After continuing the experiment for 3 hours, he found that there is no increase in respiratory exchange, either during or after the loading, thus hinting that the fastening mechanism of this shell may be due to the catch action of the muscle. BETHE (1911) investigated the consumption of carbohydrate, submitting the animal to a suspended weight for a long while, and he found that there was neither an indication of fatigue in the muscle nor a loss of weight in the fasting molluscs. KOBAYASHI (1929) estimated the lactic acid

of the adductor muscle of the oyster in loaded condition and found that the small muscle increases less in lactic acid than the larger one. These results suggest to us that power of the ligament acting on the adductor muscle needs no increase of energy loss.

On the other hand, the work of NOZAWÂ (1929) on the oyster, and COHNHEIM and v. UEXKÜLL on the leech (1912), showed that when loaded, the energy consumption of the animal becomes much greater. But the increase of energy consumption in their case may be due to the reflex movement of other muscles or organs, caused by the abnormal condition due to loading.

Comparison between the adductor muscle of Lamellibranchs and that of other animals.—

In order to compare the adductor muscle of bivalves with that of other animals, the following list has been compiled.

The power of human muscles.

Muscle gastrocnemius.	9000-10000 gms.	(KOSTER)
Flexor muscle of forarm (right).	8991 „	(HENK and KNORZ)
Flexor muscle of arm.	6670 „	(HAUGHTON)
Muscle gastrocnemius.	6240 „	(HERMAN)
Average human muscle.	8000 „	(ROSENTHAL)

The absolute power of frog muscles.

Muscle adductor magnas.	2800-3000 gms.	(ROSENTHAL)
Muscle gastrocnemius	1000-1200 „	(ROSENTHAL)

The absolute power of the craws of crabs, after PLATEAU.

Carcinus moenas de Roscoff. (left).	1336.7 gms.
Carcinus moenas de Roscoff. (right).	858.0 „
Carcinus moenas d'Ostend. (left).	1181.2 „
Carcinus moenas d'Ostend. (right).	961.6 „
Platycarcinus pagurus d'Ostend. (left).	858.0 „
Platycarcinus pagurus de Roscoff. (left).	688.9 „

CAMERANO (1892) measured the muscle power of *Carcinus*, *Eriphia*, *Talphosa* and *Astacus* and found that it ranges around 1900 gms., showing a mean value of 1850 gms.

The power of the insect muscles.

CAMERANO calculated the muscle power of fourteen species of insects and found it to be from 3600 gms. to 6900 gms.

UEXKÜLL investigated the mantelmuscle of the *Eledon* (Cephalopoda),

making an experiment in which he loaded the muscle with a weight of 30 gms., and found that the muscle, which had a dimension of $2\,\text{cm.} \times \frac{3}{4}\,\text{cm.}$ at first, was not lengthened at all.

It is evident from the above results that the absolute power of the muscle shows a distinct difference according to the species of the animal, and, moreover, that the power of the muscle of the same animal varies according to the part of the body. According to PLATEAU (1885), the mean absolute power of muscle is 1008.73 gms. in crabs and 4545 gms. in bivalves in contrast to the power of 7902.32 gms. in human muscle and 3000 gms. in frogs.

Such difference in the power of muscles may be due to the histological property of the muscle fibres.

The ratio of the power of the ligament to that of the adductor muscle. —

The ratio of the power of the ligament to the power of the adductor muscle is given in Table 40. It can be seen from this table that the value fluctuates greatly even in one and the same species, but it is 1 : 7.5 in *Paphia*, and 1 : 1053 in *Chama*, in mean. Generally, however, the results of experiments which were made on 30 species, excepting *Chama*, show that this ratio ranges between 1 : 7.5 and 1 : 71.

The ratio of the body weight to the power (W) needed in tearing off the adductor muscle. —

The ratio of the body weight to the W, that is, the power needed to tear off the adductor muscle, was calculated by the formula and is given in Table 40. This table shows us that in extraordinarily weighty species, such as *Tridacna*, *Hippoppus*, *Spondylus*, the ratio is small, giving values of from 1 : 10.2 to 1 : 30.3, but in other species it ranged between 1 : 71.4 and 1 : 566. Briefly, therefore, it may be said that the Lamellibranchs, except weighty species, open their shells only when acted on by such a mighty power as 71 to 566 times the body weight. Needless to say, the development of the power of the adductor muscle is a means of self protection for the animal against its environment. The stronger this power, the better the animals may be protected. Why weighty species are less provided with this power may be due to the fact that in weighty species the

shells are in general very thick and hence they can protect themselves by the strength of the shell itself.

A comparison of the power of the adductor muscle of tropical species with that of temperate ones would be rather worthless, inasmuch as the specific differences are too large.

SUMMARY.

1. The relation of time to weight required to tear off the adductor muscle of the tropical oyster *Ostrea dendata* has been observed, and compared with that of the temperate species, *Ostrea circumpicta*.

2. The power of the adductor muscle per sq. cm. of section area has been determined, using 30 species of tropical marine bivalves as material, and it was found to range from 1071 gms. (*Coralliophaga*) to 11381 gms. (*Chama*).

3. The power of the ligament acting on the adductor muscle has been determined from the 30 species above mentioned. The results show that the power per sq. cm. ranges between 10.7 gms. (*Chama*) and 1151 gms. (*Paphia*).

4. The ratio of the power of the ligament to that of the adductor muscle has been examined in thirty species. The results show that this value ranges between 1 : 7.5 and 1 : 71, excepting the case of *Chama* in which the ratio was far larger.

5. The ratio of the body weight to the power needed in tearing off the adductor muscle was calculated. The results show that it ranges between 1 : 71.4 and 1 : 566 in thirty species, excepting the large species, such as *Tridacna, Hippoppus*, and *Spondylus*.

6. A comparison of the power of the adductor muscle among different species of bivalves shows that the specific difference of this power among Lamellibranchs is far larger than that in other phyllum of animal so far studied by several other investigation.

7. The comparison of the power of the adductor muscle of tropical marine bivalves with that of the temperate species was almost impossible, as the specific difference is too large.

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Sex in *Stropharia semiglobata.*

By

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(With 6 Tables in the Text)

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In a paper published in 1927, CRAIGIE says that *Stropharia semiglobata* is heterothallic. But up to the present time it has not been known whether this fungus is bipolar or quadripolar. In order to determine this point the following experiments were undertaken, starting last April. Cultures were made with NEWTON's horse dung-agar at a temperature of 25°C.

About seven monosporous mycelia were at first isolated from a single fruit-body found in the suburbs of Sendai. This fruit-body will be referred to hereafter as (M). All possible pairings of these mycelia were made. The following Table I is the result. In the table the sign (+) indicates the presence of clamp-connection, and the sign (−) the absence of the same after the union of the two mycelia.

TABLE I.

	1	2	3	4	5	6	7
1	−	−	−	−	−	+	+
2	−	−	−	−	−	+	+
3	−	−	−	−	−	+	+
4	−	−	−	−	−	+	+
5	−	−	−	−	−	+	+
6	+	+	+	+	+	−	−
7	+	+	+	+	+	−	−

The same experiment was repeated in another fruit-body (N) found in a playground of Sendai. The result is shown in Table II.

TABLE II.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	−	−	−	−	−	−	−	+	+	+	+	+	+	+
2	−	−	−	−	−	−	−	+	+	+	+	+	+	+
3	−	−	−	−	−	−	−	+	+	+	+	+	+	+
4	−	−	−	−	−	−	−	+	+	+	+	+	+	+
5	−	−	−	−	−	−	−	+	+	+	+	+	+	+
6	−	−	−	−	−	−	−	+	+	+	+	+	+	+
7	−	−	−	−	−	−	−	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+	−	−	−	−	−	−	−
9	+	+	+	+	+	+	+	−	−	−	−	−	−	−
10	+	+	+	+	+	+	+	−	−	−	−	−	−	−
11	+	+	+	+	+	+	+	−	−	−	−	−	−	−
12	+	+	+	+	+	+	+	−	−	−	−	−	−	−
13	+	+	+	+	+	+	+	−	−	−	−	−	−	−
14	+	+	+	+	+	+	+	−	−	−	−	−	−	−

In the next place the pairings of the mycelia originated from the fruit-bodies (M) and (N) were examined. The result is shown in Table III.

As is shown in the table, in this case all combinations produced clamp-connections, so the fruit-bodies (M) and (N) appear to belong to two different geographical strains. The sex factors of these strains are called A_1, A_2 and A_3, A_4 respectively. Among the monosporous mycelia shown in the tables No. 1–5 (Table I) belong to A_1, No. 6–7 (Table I) to A_2, No. 1–7 (Table II) to A_3, and No. 8–14 (Table II) to A_4.

TABLE III.

			N				Mono-sporous culture
			A_3		A_4		
			2	6	9	10	
M	A_1	2	+	+	+	+	−
		4	+	+	+	+	−
	A_2	6	+	+	+	+	−
		7	+	+	+	+	−
Monosporous culture			−	−	−	−	

For further experiments I used another fruit-body (O), which was produced by the union of the two monosporous mycelia from the fruit-body (M). The result of pairings of ten monosporous mycelia from the fruit-body (O) with its parent monosporous mycelia No. 2 and No. 6 and with monosporous mycelium No. 10 from the fruit-body (N) is shown in Table IV.

TABLE IV.

			O										Mono-sporous culturs
			A_2							A_1			
			1	2	3	4	5	6	7	8	9	10	
M	A_1	2	+	+	+	+	+	+	+	−	−	−	−
	A_2	6	−	−	−	−	−	−	−	+	+	+	−
N	A_4	10	+	+	+	+	+	+	+	+	+	+	−
Monosporous culture			−	−	−	−	−	−	−	−	−	−	

To test the Mendelian segregation of the sex factors, a series of monosporous mycelia from two fruit-bodies (P and Q), both produced by the union of two different geographical strains, were brought into contact with different monosporous mycelia. The result is shown in Tables V and VI.

TABLE V.

				P						Mono-sporous culture
				A_4					A_2	
				1	2	3	4	5	6	
Parent mycelia of P	M	A_2	7	+	+	+	+	+	−	−
	N	A_4	10	−	−	−	−	−	+	−
	N	A_4	11	−	−	−	−	−	+	−
	N	A_3	6	+	+	+	+	+	+	−
Monosporous culture				−	−	−	−	−	−	

TABLE VI.

				Q											Mono-sporous culture
				A_2					A_3						
				1	2	3	4	5	6	7	8	9	10	11	
Parent mycelia of Q	M	A_2	7	−	−	−	−	−	+	+	+	+	+	+	−
	N	A_3	6	+	+	+	+	+	−	−	−	−	−	−	−
	N	A_4	11	+	+	+	+	+	+	+	+	+	+	+	−
Monosporous culture				−	−	−	−	−	−	−	−	−	−	−	

CONCLUSION.

1. The sex in *Stropharia semiglobata* is bipolar.
2. Geographical strains differing in sex factors exist also in this fungus. Fruit-bodies are always produced by the union of any two monosporous mycelia from the different geographical strains.
3. The Mendelian segregation of the sex factors in the crossing between two different geographical strains is complete.

I wish to express my hearty thanks to Professor M. TAHARA for his kind advice and assistance throughout the progress of this work. I am also deeply indebted to Dr. S. KAWAMURA, Professor in the Horticultural College of Chiba, for the species-determination of this fungus.

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A Note on *Pheretima sieboldi, Horst.*

By

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(With 2 text-figures.)

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1. *Megascolex sieboldi*, n. s. Notes Leyd. Museum, Vol. V, 1883, PP. 191.
2. *Perichaeta sieboldi*, ROSA, Ann. K. Hofm. Wien. Bd. VI, 1891, PP. 401.
3. *Pheretima sieboldi*, BEDDARD, Zool. Jahrb. syst., Vol. VI, PP. 759. 1892.
4. *Amyntas sieboldi*, MICHAELSEN, Mt. Mus. Hamburg, Vol. XVI, PP. 4, 1899.

One of the oldest known Japanese earthworms, first described by HORST nearly a half century ago, and one of the species best known to the western world is *Pheretima sieboldi*. This species attracts the attention of students not because the name of a most eminent scientist is attatched but because it is perhaps one of the largest terricolae found in Japan.

Nearly thirty years ago the present writer, in collaboration with Prof. SEITARO GOTO, made collections of the earthworms in Japan and described several new species of Pheretimas found there.

Curiously enough, though the range of our collections was rather limited to the central part of Japan, not only were we unable to find this species, but we were unable also to rediscover among our collections many of the Pheretima species already described by several European writers. Briefly it is more gratifying at the beginning of a biological survey to re-identify the known species than to discover new species.

At the same time, we found abundantly in all localities where collections were made a species which closely resembles *Pheretima sieboldi* in nearly all taxonomic characters with the exception of the different positions of three pairs of spermathecae. Since the position of the spermatheca is a most important taxonomic character differentiating the species and since the present form is widely distributed in Japan, we decided it was a hitherto undiscribed species and introduced it as a new species, *Perichaeta communissima*. BEDDARD ('00), however,

hastily amalgamated *P. communissima* to *P. sieboldi* of HORST and states "Some confusion has arisen concerning this species owing to the fact that the examples studied by GOTO and HATAI showed the spermathecae in VI–VIII, instead of in VII–IX as described by HORST, ROSA, and MICHAELSEN." BEDDARD goes on further to state "The latter (MICHAELSEN) now solved the dificulty by finding that in some specimens, which he distinguishes as a variety lenzi, the spermathec. e have that position."

To these remarks I answer with one word that *Perichaeta communissima* is perhaps the most stable species found in Japan and indeed I have not yet found a single case of displaced position of spermathecae from the norm, among several hundreds used annually for various laboratory work. The name was given after examination of hundreds and not after examination of a few worms. Consequently BEDDARD was unjustified in uniting the two species and in placing *Pheretima communissima* GOTO and HATAI) as a synonym of *Pheretima sieboldi* (HORST).

The confusion, however, could not be cleared up entirely until *Pheretima sieboldi* was rediscovered and the two species compared side by side. I made a special trip to Nagasaki where Dr. VON SIEBOLD resided and searched after this gigantic specimen in the city as well as in several nearby villages. A search was even made by digging at several spots in the ground, where Dr. VON SIEBOLD had actually resided. All these efforts ended in vain and the species was not found even among extensive collections obtained on that occassion in several other localities in Kyushu including Kagoshima, Kumamoto, Miyasaki and Fukuoka.

My long continued efforts were finally rewarded on a recent trip to Shikoku where I obtained the two adults through the courtesy of Prof. NENJI KAMBARA of Kôchi College, and I wish to thank him for his generosity in giving me an opportunity to examine this long searched for earthworm and also in giving me a chance to satisfactorily clear up this long standing confusion.

The original description of HORST on this species read as follows:

"*Megascolex sieboldi* n. s. Cephalic lobe rounded behind, reaching half the buccal segment. Orifices of the copulatory pouches between the 6th and 7th, 7th and 8th, 8th and 9th segment; opening of the

oviduct. Number of setae on each segment 80, but the cincture without bristles. There are no papillae on the ventral side. The dorsal pores are commencing between the 12th and 13th segment. The copulatory pouches are situated to the number of three pairs in the 7th, 8th and 9th segment; each of them consists of two parts: a large pear-shaped vesicle, with a short duct. and a tube, somewhat longer than the vesicle and plicated like in *P. Houlleti* PERR. Male genital organs placed in the 11th and 12th segment; prostatic glands large, divided in lobes by deep incisions. The 5th and 6th septum bear groups of glandular tubes on their anterior side; the 8th and 9th septum are wanting. In the 26th segment the intestine is provided on each side with six conical coeca, placed on a transverse series; the superior is the longest, extending forwards into the 21st. segment and it seems to represent the single caecum of other *Megascolex*-Species. Length 270 mm., circumference of body 30 mm., number of segments 135.

Hab. Japan (VON SIEBOLD).

I shall now describe briefly the main features of *P. sieboldi* based on these two adult specimens.

Pheretima sieboldi is certainly a large sized worm, as it was stated by HORST, and my specimens give the following dimensions:

	1.	2.
Body length	247 m.m.	280 m.m.
Body width	14 mm. in X.	15 mm. in X.
Number of segments.	127	152

The color of the worm is very light gray in formalin preserved specimens.

Positions of the spermathecal openings, as it had been stated by HORST, are found in VI/VII, VII/VIII and VIII/IX instead of V/VI, VI/VII and VII/VIII as in *P. communissima*. The openings are rather small and inconspicuous for the size of the worms and no genital papillae of any form are present in the neighborhood of the openings. Within each opening is noted a small papillary projection on which the spermathecal duct opens.

The ovidual pore is surrounded by small discolored circular area and is located in the ventral side of the usual XIV segment. The clitellum is smooth and lacks setae.

Fig. 1.

Fig. 2.

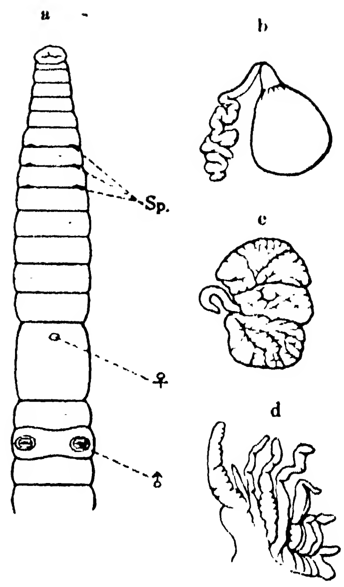

Fig. 1. *Pheretima sieboldi*, HORST (a and b).
Compared with *Pheretima communissima* GOTO and HATAI (c).
Attention is called to the relative size of these two species.

Fig. 2. a. Ventral view of P. sieboldi. sp. Spermathecal openings; ♀ oviducal pore; ♂ Male openings.
b. Spermatheca;
c. Prostate-gland with curved muscular duct M.
d. Intestinal coecum with several projections.

The dorsal pore commences, as HORST states, in XII/XIII.

The male pores are located in XVIII and open on top of a somewhat elevated area. The pores are separated by 15 setae. In *P. sieboldi* the openings are situated much closer to the ventral median line than in *P. communissima* in which the openings are located almost in the lateral edges of the body.

The most conspicuous difference between the two species under consideration is noted in the form of the spermathecae. *P. sieboldi* possesses a very short duct compared with the size of the ampula, the former being less than a third of the later, while in *P. communissima* the duct is longer and the ampular is globular instead of oblong or pear shaped. Such an oblong ampula with very short duct is still better seen in an immature specimen.

The diverticulum is much twisted in both species but is more complicatedly wound and twisted in *P. sieboldi* than in *P. communissima*. The male duct, or a duct leading from the prostate gland to the external orifice, in *P. sieboldi* is short while it in *P. communissima* it is considerably longer.

When we come to details, there are many other more or less conspicuous differences but suffice it to say that *P. sieboldi*, HORST is different from *P. communissima* GOTO and HATAI and these two species are independent of each other.

It now became clear that the reason why *P. sieboldi*, HORST escaped rediscovery for so long was while our strenuous efforts of searching were directed to the gardens, refuge piles, pastures etc. where most of the Pheretimas are normally inhabited, in reality, *P. sieboldi* is normally found in the mountain passes or along lonely roads. It is not a species of common occurrence such as *P. communissima*. Furthermore, *P. sieboldi* is a typical inhabitant of the southern part of Japan while our searches or collections were carried on chiefly in the northern and central parts of Japan. It is also to be added that a majority of the earthworms examined by Europeans were the forms which are mostly found in the south of Japan and indeed my recent collections made in Kyushu and in Shikoku brought out several species which were described by them. The European writers did not evidently appreciate the richness of Pheretima fauna both in numbers and species and thus they attempted to forcibly amalgamate many subsequently described new species to the few species already described by their hands. I have already pointed out such mistakes in connection with several species (HATAI 24, 29, 30), and in forthcoming papers I hope that I shall be able to straighten up most of the confusions which arose from such assumptions.

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Ecological Observations on *Acmaea dorsuosa* GOULD.*

BY

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(With 5 text-figs and Pl. XII.)

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INTRODUCTION

Acmaea dorsuosa GOULD belong to Docoglossa of Gastropoda and are commonly found in Mutsu Bay attaching to the rocks, especially over the high-water mark, as though these molluscs perform terrestrial life. With the thought that the studies on the habits and physiological characteristics of these limpets might throw some light on the understanding of evolutionary processes from an aquatic life to a terrestrial one, the following investigations were carried out. The observations and experiments have been done at Asamushi Marine Biological Station.

Here I must express my hearty thanks to Prof. S. HATAI for his kind direction in the preparation of this work, and to Prof. E. NOMURA and Assistant Prof. S. KOKUBO and others who helped me in many ways while the investigation was progressing.

I. FORMATION OF COLONY.

1. Spring and Summer Seasons.

At about the 10th of April, 1930, I found *Acmaea dorsuosa* GOULD here and there in groups on the rocks around the islands Yunoshima and Gomishima, near the Station. These limpets are found forming groups on such rocks which are faced to the south-west or north, thus receiving the afternoon sun directly on them, though some of them are found where the sun shines a short while before sunset. Without exception the rocks where the limpets live, are more frequently

* Contributions from the Marine Biological Station, Asamushi, Aomori-Ken. No. 66.

washed by surging waves than other rocks where these are not found. Although a single group of the limpets may consist of about ten individuals to over two hundred and fifty individuals, those which are composed of 30 to 50 individuals are more frequently met with. Most of the limpets are found facing their head ends downward or toward the water surface. The various directions indicated by the head ends of limpets are shown in Table I.

TABLE I. Directions of the limpets on the rocks shown by degrees.

No.	0°	45°	90°	135°	180°	225°	270°	315°	Total
1	—	—	—	—	—	8	3	3	14
2	—	—	—		—	9	5	5	19
3	3	—	—	—	1	3	8	4	19
4	—	—	—	—	3	7	7	3	20
5	2	1	—	.	—	7	8	7	25
6	1	—	—	—	2	7	9	6	25
7	1	—	—	1	2	5	13	4	26
8	1	—	—	—	—	8	17	5	31
9	—	2	—	1	1	6	16	5	31
10	8	2	2	1	4	13	13	12	55
Total	16	5	2	3	13	73	99	54	265

0° represents a limpet facing with the head end to the right side, 90° upward, 180° to the left side, and 270° down-ward.

In Table I, we can see that 226 individuals among 265 individuals are resting head end down or 225° to 315°, while only 10 individuals are facing head side up or 45° to 135°.

II. Autumn and Winter Seasons.

So far as my observations go, the limpets appear to remain in their respective groups about five months (from April to the middle of September), only dissolving their colony after this period when Mutsu Bay begins to rage. September the 15th, after a storm of several days, I found all the limpets scattered here and there one or two metres away from their original home and with no definite colonies to be seen in the same place where they were only a few days before. After this period when the sea becomes rougher and waves become higher together with a further fall of the temperature of the sea water, some of the limpets are found moving themselves still higher on the

rocks, the greatest height attained by some of the limpets being about three metres above the original home. On the other hand, some of the limpets crawl downwards towards the water surface but whether or not they actually enter into the water can not be determined. In short, such scattered limpets appear to live isolately without re-forming a group till the winter is over.

Even in the same island, where the waves are not so violent, some limpets were found to remain as before forming a group and indeed I noticed three such instances, as follows:

Case I. This group consisted of 16 individuals and was located 1.1 metres above low-water mark, and 2 metres away from the beach, on a broad and comparatively flat rock, faced to north-east.

Case II. This group consisted of 26 individuals, near the first group on the same rock.

Case III. This group consisted of 31 individuals, near the two other groups on the same rock.

The horizontal distance of dispersal after disolution of the group is seldom over 3 metres from the original home, but if the surface of the rock is smoother, most of the limpets remain within 2.3 to 2.7 metres. I however noticed several limpets which moved land-ward as far as 4.2 to 5.2 metres, but never more than 5.2 metres so far as my observation is concerned.

II. HABITS.

I. Locomotion.

Acmaea dorsuosa does not move in the day time in natural habitats, but in the laboratory when placed on a vertical glass plate in the water, the limpet begins to crawl before long, even during day time.

1. How they creep. The limpet sucks on a plate with the foot surface, and the two rows of waves of the foot muscle pass over the surface from anterior to posterior, one along the left side and the other along the right side separately, three crests of waves on one side and the two on the other side of the foot surface, alternatively. This mode of locomotion evidently belongs to the so-called subtype "Ditaxic movement" of "Direct type". (Vles, '07)

G. H. Parker ('11) mentions, relating to the locomotion of Gastro-

poda, "None, so far as I am aware, can reverse and move backward as, for instance, an earthworm can". According to my observation however, though *Acmaea dorsuosa* crawls in a forward direction only

TABLE II. Time of locomotion.

Date	Beginning time	Ending time	Period of locomotion	Day or night
July 21st	p.m. 10 30	a.m. 1	2 30	N
22nd	p.m. 10	a.m. 5	7	N
23rd	p.m. 7 & a.m. 3	a.m. 2 30 & a.m. 4 30	5 & 1 30	N & D
24th	p.m 10 30	a.m. 5	6 30	N
25th	p.m. 7 30	a.m. 4	8	N
26th	p.m. 10	a.m. 3	5	N
27th	p.m. 9 30	a.m. 3	5 30	N
28th	p.m. 8	—	—	N
29th	p.m. 8	p.m 11 30	3 30	N
30th	p.m. 7 30	a.m. 3 30	8	N
June 1st	a.m 1 30	a.m. 5 30	4	N
2nd	p.m. 9	a.m. 11	14	N & D
3rd	p.m. 0 & p.m 7 30	p.m. 1 & —	1 & —	D & N
4th	p.m 9	a.m. 1 30	4 30	N
5th	p.m. 9 30	p.m. 11 30	2	N

TABLE III.

No	Novement was recorded			No movement was recorded	Total number of days observed
	At night only	At day only	Both at night and at day		
1	13	0	0	0	13
2	12		0	1	19
3	12	1	0	2	15
4	14	0	2	0	16
Total	51	7		3	63

under normal conditions, when, for instance, disturbed suddenly by sticking gently with a needle point, it crawls backward about one or two centimetres without turning the direction of its body. I have also

noted such reverse locomotion in the movement of *Acmaea schrenckii* var. *concinna* LISCHKE, when it was suddenly disturbed by the similar method to that mentioned above.

The velocity of locomotion of *Acmaea dorsuosa* is about 2.8 centimetres per minute, and of *Acmaea schrenckii* var. *concinna* 8.6 centimetres per minute.

2. Locomotion in the laboratory.

The movement of a limpet in a water tank was recorded by kymographic method by cementing one end of a thread to the top of the shell and tying the other end to a lever. The water in the tank was kept constantly flowing. The kymographic record is shown in Figure 1.

Fig. 1. Kymographic record of locomotion.

The data on the locomotion given in Table II was obtained from the kymographic records. From Table II, it is evident that the limpet is comparatively active at night. Such nocturnal activity can also be seen from Table III, in which the movement of 4 limpets is shown. It is clear that the limpets move almost exclusively at night thus recording active movements on 51 nights out of 63 days.

3. Locomotion in natural habitat.

Field observation was made in lodging at Gomishima Island, visiting round the colonies of the limpets every other hour during several nights. I also cemented a thread on a shell with the other end rolled to a reel, with the hope that the movement might be registered from the length of thread reeled out.

After such observations, direct and indirect, it became clear that

any movement of *Acmaea dorsuosa*, longer than one centimetre, has no relation to the ebb and flow of the tide, and they only show movements when the high wave sprushes over the shells at evening or at night. So far as my observations go, the limpets in natural state do not move in the day time. It may be added that even when several limpets start their wandering within a colony, the majority of them remain quiet, though eventually they all show wandering at least once in 12 or 15 days.

I now wish to show an example in which a limpet moved searching after food. At 5 o'clock on the evening of the 29th of July, a limpet was found creeping on a rock in the dim light. It was just the time of the high-tide and the crumbling waves had been washing over it, it crawled almost horizontally about ten centimetres up from the water level. This rock was covered with microscopical algae. Next morning, this limpet was found resting at a point 65 centimetres away from the point where it was feeding the previous evening. Two days after, its position was 1.3 metres away from the first position.

Preceding descriptions on locomotion are true with the large limpets, longer than 1.5 centimetres, but smaller ones may creep even at day time under direct sunlight, when the waves sprush over them.

As regards *Patella vulgata*, J. H. ORTON ('29) gives a detailed description but for convenience I shall first present short statements given by several investigators as quoted by RUSSELL ('07). "LUKIS, JEFFREYS, and ROBERTSON state that the limpet wanders when covered by the tide; DAVIS and FISHER that it wanders, while uncovered, and FISHER that young ones wander only when covered; BOUCHARD-CHANTERAUX that it makes excursion just after the tide goes out; LLOYD MORGAN that it wanders chiefly as the tide leaves it and as the tide returns; LLOYD MORGAN and ROBERTS are of the opinion that it does not move about when submerged". RUSSELL ('07) himself found that larger limpets, more than 2.0 centimetres, did not creep when the tide did not come, and that little ones creep at any time. ORTON ('29) says that the creeping of the limpet is associated with various factors within it and not connected with the tide.

Note to the locomotion:

Comparing the locomotion in the laboratory with that in natural habitats, it was found that in the former case, the limpet

creeps almost every night but in the latter case, it creeps only once in 12 days. So that we may infer that the locomotion noted in the laboratory may have been forced reaction in searching for a more convenient place.

II. Problems on Home or "Scar".

It has been known since the days of ARISTOTELES that *Patella vulgata* has a home and returns to the "Scar", even after wandering some distance in search of food. The problems concerned with the home were discussed lately by RUSSELL, PIERON, LOPPENS, ORTON and others. ORTON ('29) agrees with LOPPEN and says that the limpet has a home but that it is not the final dwelling, and that if the limpet finds a more comfortable place, it will change to the latter.

Also in *Acmaea dorsuosa*, such a home can be seen. For the sake of this observation, I drew a line which marked the ends of the shell and the rock with red enamel, in order to observe whether it can return to the same spot. Generally the limpet returns to this spot exactly. Several times, I placed a piece of thread on this spot while the limpet was wandering, but it returned to this very same spot and rested itself on the thread, nevertheless. From the above it seems reasonable to conclude that *Acmaea dorsuosa* has a home. But it is not always the case that the limpet returns to its home, since it was noted several times that some of them did not return, having mingled and stationed with an other group.

Whether or not the younger limpets, smaller than 1 centimetre, also form a home as the larger specimens do, I am unable to state definitely, but, as Table IV shows, the younger specimens show profound wandering behavior as if they

TABLE IV. The number of limpets collected.

Date of collec.		Numbers
April	19th	232
	23rd	60
May	2nd	40
	9th	51
	16th	60
May	23rd	12
	29th	82
June	5th	114
	21st	127
	29th	133
July	8th	227
	16th	278
	26th	377
August	—	—
Sept.	6th	113
	16th	130
Sept.	26th	72
Oct.	10th	138
	28th	13
Total		2259

do not possess a home. For this reason, I collected all the limpets which appeared on an isolated little rock about 3 metres by 2 metres above the water line for every 7 or 10 days from April to October. These results are shown in Table IV.

It was found that in the first collection (19th, April) 54 larger limpets, longer than 1.5 centimetres, were present; on the 23rd, or in the second collection, only 5 such larger individuals were found; and on May 2nd, or in the third collection, only one larger individual was found. After the 9th of May only the smaller limpets of less than 1.25 centimetres were collected. So it is clear that the limpets which climb up from the water are chiefly smaller or younger ones between 12.5 mm and 4 mm of shell length.

Here, we must notice that when autumn comes, the limpet leaves the home and wanders here and there, and re-forms a home in the next spring, but it is not yet determined whether they do return to their original homes or not.

III. Sucking power and righting reactions.

Acmaea dorsuosa creeps while strong waves are crushing over it, without being washed away from the rock, and also needs a considerable force to be separated from the rock. How the limpet produces such a force and how strong is the force are interesting problems to study.

At first I measured their sucking powers. This method of measurement is very simple though it is rought. Namely, putting a limpet on a glass plate about 10 centimetres square, to the ends of which a shallow box to hold weights was hung. After one hour, I held the shell and by degrees the weights were placed on the box, until the limpet was separated from the glass plate. The weights required to separate the limpet from the plate are shown in Table V.

In Table V, the value given under W_1 is the experimental result of the sucking power expressed by the weights required, and W_2 was obtained by multiplying to the foot surface, 76 (cm), one atmospheric pressure in mercury tube, and 13.65 (specific gravity of mercury), with a view to calculating the force of a perfect vacuum at one atmospheric pressure. Therefore, $W_1/W_2 \times 100$ should show the limpet's ability of vacuum formation. 100% means the physical perfectness of vacuum formation. In the table, No. 9 shows 186.9%, but this

TABLE V. Sucking power of the limpet.

No.	Length of shell	Foot area in cm.²	Amount of weights required in grs. W_1	Theoretical amount of force necessary to separate the foot from the glass. W_2.	W_1/W_2 100
1	26.30	2.65	1398.7	2738.2	51.1%
2	26.30	2.50	1263.7	2583.2	48.9%
3	26.30	2.57	1033.3	2655.6	38.9%
4	22.75	1.93	243.7	1994.3	12.2%
5	22.45	1.71	612.5	1766.9	34.6%
6	22.45	1.73	1027.5	1787.6	57.4%
7	22.45	1.72	1500.0	1777.3	84.4%
8	22.40	1.80	498.7	1859.9	26.8%
9	21.25	1.47	2839.7	1518.9	186.9%
10	20.60	1.79	188.7	1849.6	10.2%
11	19.60	1.35	350.0	1394.9	25.1%
12	18.30	1.46	577.5	1508.6	37.6%
13	17.55	1.06	247.5	1095.3	22.6%
14	17.30	1.23	243.7	1270.9	19.1%
Mean					36.1%

is no doubt due to mucus's conhesion, in addition to the vacuum formation. The average values from the present test shown are that 1 square centimetre of the limpet's foot surface has a force corresponding to about 373 grams or more.

It is evident from the above that the limpet possesses some considerable sucking power. It follows to determine whether the limpet can regain its natural position when it is placed upsidedown as, for instance, when it falls from a rock to the bottom of the sea. I tested its righting reactions by putting it upsidedown on the flat wooden bottom of a water tank. It was found that the limpet under such circumstances could not turn itself right side up. Even when the tank bottom was inclined about 45 degrees or as much as 60 degrees, it failed to regain its natural position. I undertook the same experiment in its natural habitat. First, I dropped at random several limpets from their homes, and watched their behavior for a few hours. Some which fell on a shallow place, did got up aided by the wave; others which fell between two rocks, sucked swiftly to the rock and got up, but the rest which fell on the flat waveless bottom could not regain their normal side up, but after a few days they were found dead in

their abnormal position though their real cause of death is not yet clear. Furthermore, the larger limpets can not move from one plane to another plane, which stands at right angles. All these facts seem to show that when they fall from their homes, a majority of them can not regain their side up and death is inevitable, so that it is a well adapted character that they possesses a great sucking power.

IV. Amount of water stored within the shell.

Acmaea dorsuosa lives in the air, and can live a long time only in the air. A limpet, kept in a tightly closed glass vessel of about 3000 cc volume, in which a little amount of sea water was placed for preventing dryness, survived 149 days in one case and 109 days in another case.

TABLE VI. Amount of sea-water contained.

No.	Shell length	$\frac{L+B}{2H}$	Body weight	V in cc
1	28.60	2.002	3.718	0.869
2	28.20	1.768	3.912	1.265
3	27.50	1.730	3.038	1.295
4	27.30	1.742	3.656	1.654
5	27.00	1.615	4.447	1.091
6	27.00	2.014	3.364	0.923
7	26.90	2.048	3.204	0.938
8	25.85	2.074	3.236	0.737
9	25.20	1.309	3.339	0.764
10	24.95	2.082	2.665	0.822
11	24.45	1.495	3.111	1.049
12	24.10	1.512	3.414	0.813
13	23.95	1.946	3.076	0.828
14	23.90	1.946	2.900	0.750
15	23.60	1.916	2.486	0.922
16	23.35	1.883	2.665	0.699
17	23.35	1.832	2.215	0.904
18	23.20	1.519	2.397	1.121
19	22.70	1.981	2.071	0.642
20	22.55	1.956	2.206	0.768
21	22.00	1.729	2.186	0.912
22	22.00	1.845	2.011	0.905
23	21.75	2.249	1.462	0.428
24	21.50	1.740	2.260	0.765
25	21.25	1.840	2.210	0.591
26	21.20	1.915	1.682	0.594
27	21.15	1.895	2.142	0.720
28	21.00	1.665	2.080	0.591
29	20.20	1.714	1.863	0.626
30	19.95	2.041	1.369	0.496
31	19.85	2.269	1.165	0.468

It was noticed also that limpets can recover when placed into sea-water, even after their tentacles and feet have been dryed and hardened to a light brown colour.

But in the limpet, some amount of sea-water is normally included between the mantle and the shell or in the subnuchal cavity. The amount of water contained in the subnuchal cavity and in other parts is shown in Table VI.

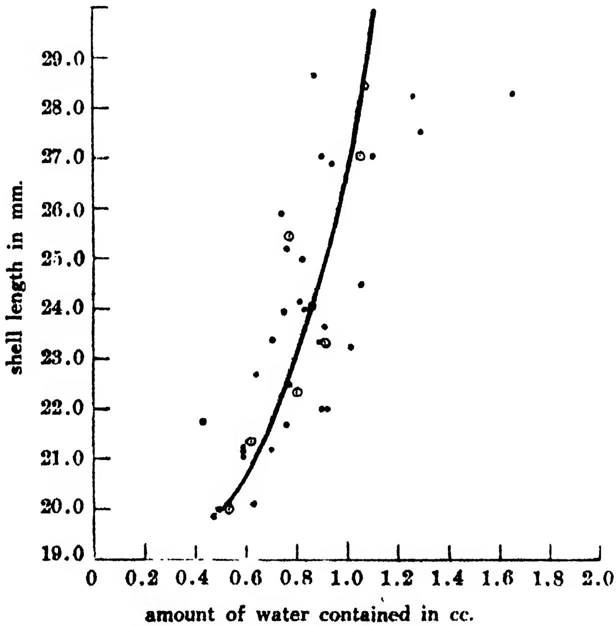

Fig. 2. Shell length and the amount of water stored.

In Table VI, L=shell length in mm, B=shell breadth in mm, Body weight=weight of the living limpet including shell without water stored in the subnuchal-cavity etc., V=volume of the water in cubic cm, (L+B)/2 H=dimension which express the relation of the shell length and the breadth to the shell height H. From the dimension thus deduced, G. H. ORTON found that in *Patella vulgata*, it varies from 2.55 to 2.81, at neap tides, in specimens longer than 3.5 centimetres, while those occuring above high-water neaps show a variation from 1.81 to 2.25.

I found in *Acmaea dorsuosa* shells which measure from 13.25 mm

to 32.50 mm, so that their dimensions, $(L+B)/2H$, vary from 1.22 to 2.48, based on the measurments made on about 330 individuals, collected from Ohshima Island above high-water neaps.

Fig. 2 shows the relation between shell length and "stock water". The relations is expressed by the formula $y = ax' + b$; where y=shell length in mm., x=volume of stock water in cc., a=constant characteristic to the graduations of X and Y axes, b=constant and is related to shell length. In Fig. 2, the points with small circles are observed mean values and the continuous line was drawn according to the formula

$$y = 8x' + 19.0$$

From this curve we notice that the smaller limpets possess a much greater amount of stock water than that found in the bigger ones in their respective shell lengths.

Specific gravity of the stock water was 1.0249, but at Sept. 9th, the day that the limpets were collected, the specific gravity of the sea-water was 1.0246. The stock water exhibits a light yellowish colour and tastes salty. The real significance of the stock water is not yet clear but appears to me to protect from dryness of the body, pallial gills etc.

III. TROPISMS.

On the study of the animal behavior, it seems very important to examine their tropism phenomena. As the first step I attempted to determine the physiological state in its relation to the behavior.

If the limpets, *Acmaea dorsuosa*, are placed on the wall of a water tank, they assemble themselves in a line as shown in Fig. 3, at the darkest spot near the outflow of the water. All seven limpets were found head side down, and their shell-ends were either submerged or exposed from the water surface. The phenomena, just noted suggested at first to me thigmotaxic reaction and consequently I made tests with many models of limpets made of cement or with real shells filled with cement, placing them near the water surface, but the results were entirely negative; that is, the limpets did not show taxis to these models.

As for phototropism, I found that larger limpets are negative

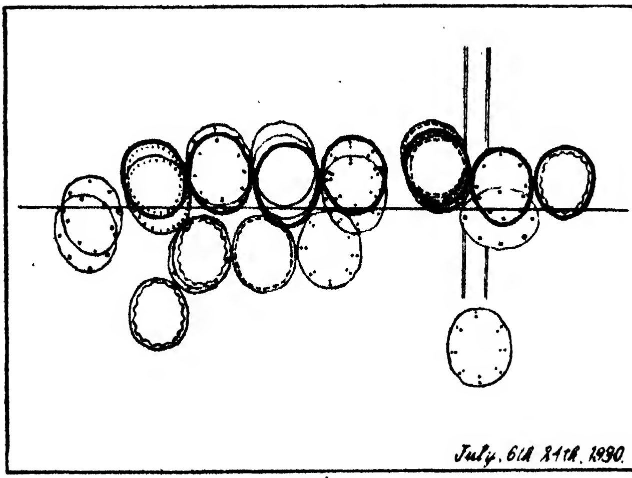

Fig. 3. Positions of the limpets in the water tank. Holizontal line shows the water surface.

under defused light in the room. On the other hand, the smaller ones, about 8 or 9 mm., are positive under the same condition, but negative to direct sunlight. Moreover, the shading reaction can be seen in both smaller and larger limpets. I often noted that if one throws a shadow on the limpet in movement with a finger from about one metre's distance, the limpet stops movement suddenly.

Concerning the *Patella vulgata*, both C. LLOYD MORGAN and G. BOHN ('09) observed that it tends to change its body direction under experimental conditions, just the same as if it lived in nature. I have also noted accidentally while playing the limpets with a pipette, that they turned their heads toward the direction of the current source. All these facts suggest that so-called Geotropism and Rheotaxis may play important roles in this reaction of direction change.

1. Geotropism.

Among Gastropoda, the geotropism was examined with the following species: *Helix pomatia*, *H. hortensis*, *H. nemoralis*, *H. arbustorum*, *H. ericetorum*, *Limnaeus stagnalis*, *Limnaeus elodes*, *Arion emplicorum* (above, by BAUNACKE, '14); *Arion hortensis* (BAUNACKE and PLATE); *Limax maximus* (BUDDENBROCH, '13 and PETER FRANDAEN, '01); *Limax agrestis*, *Limax laevis*, *Limax arborum* (BAUNACKE, '14); *Physa*

(JEAN DAWSON, '11) etc.

I have examined the same reaction of the species: *Acmaea dorsuosa* and *Acmaea schrenckii* var. *concinna*.

METHOD:

On the wall of a cylindrical large glass vessel, (diameter 32 centimetres, height 30 centimetres,) into which fresh sea-water was poured to the height of 20 cm. from the bottom, the limpet was placed at 15 cm. below the water surface. The crawling of the limpet was registered with a dot on the outer wall for every one minute in marking the movement of the anterior middle end of the shell, with blue water colour. I have traced the movement until the limpet stops its crawling spontaneously. Finally, the trace thus registered on the glass wall was reproduced on a blotting paper, and the nature of the geotropism was thus studied.

TABLE VII. Geotropism, Experiment I.

No.	Atmospheric temperature C°	Sea-water temperature C°	Shell length in mm.	Time used to complete the circus movement in minutes	Time creeping used to touch the water line in minutes	Stoped point + over the water line −under the water line	Direction of body in degrees	Inclination angle of passage	Maximum velocity in m.m. per minute	Geotropism
1	25.1	24.3	25.25		19	−84	48	− 9	5.5	−
2	25.1	24.3	23.95		24	+ 5	84	− 8	9.0	−
3	26.9	25.2	23.75		8	+30	275	−33	28.0	−
4	28.2	24.6	22.90		27	−67	74	−31	4.0	−
5	26.2	25.0	22.80		8	+ 2	256	−22	28.0	−
6	28.1	24.5	22.80		18	+15	40	+19	19.0	−
7	27.0	25.5	22.15		25	+ 8	76	− 5	16.0	−
8	28.2	24.6	21.75		8	+37	272	− 2	26.0	−
9	27.0	25.5	21.45		18	−58	67	− 9	11.0	−
10	29.0	24.3	21.35		12	+ 5	258	+10	17.0	−
11	26.2	25.5	21.05		20	−73	92	− 1	5.0	−
12	25.9	24.3	21.05	7	13	− 4	259	+ 1	17.0	−
13	25.9	24.3	20.90		30	−87	93	+20	10.0	−
14	27.2	24.6	20.55		17	+ 5	101	+ 7	14.0	−
15	25.8	23.9	20.25	3	19	+ 5	88	+10	17.0	−
16	26.5	24.2	19.75		12	+18	100	−19	15.0	−
17	27.2	24.6	19.05		14	+ 7	63	+ 4	17.0	−
Mean	25.1 29.0	23.9 25.5	19.05 25.25		16	−14	74 262	− 4.6	15.0	100%

Experiment I. *Acmaea dorsuosa*, placed head side up.

All the experiments of geotropism were carried under defused light in the room, and one limpet was used only once. Those data in which the limpet either dropped or stopped its crawing from some disturbing causes, as a loud noise or my own shadow, were excluded from general treatment.

In experiment I, the limpets were placed head side up. Although I have tested 30 individuals, since most of these lack the temperature data, I have given in Table 7 only those 17 cases in which the temperature was recorded.

Experiment II. *Acmaea dorsuosa*, placed head side down.

In Experiment II, the limpets were placed head side down, because, in the results obtained from Experiment I, it might be considered

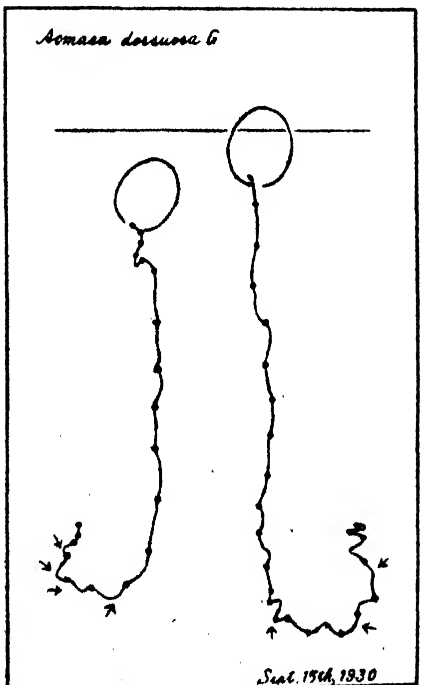

Fig. 4. Tracing the movement in Experiment II.

that the limpets crawled straight forward, pointing their heads toward the water surface. In spite of the fact that the direction of the animal

was exactly opposite that in Experiment I, or head side down, the limpets turned their body direction and crawled upward as in the case of the first test. An example of such locomotion is shown in Fig. 4, and the data from the experiment are shown in Table VIII.

TABLE VIII. Geotropism, Experiment II.

No.	Atmospheric temperature C°	Sea-water temperature C°	Shell length in mm.	Time used to complete the circus movement in minutes	Time creeping used to touch the water line in minutes	Stoped point + over the water line − under the water line	Direction of body in degrees	Inclination angle of passage	Maximum velocity in m.m. per minute	Geotropism.
1	22.6	21.7	26.90	7′	24′	− 95	121		5	−
2	22.6	21.7	26.80	7′	24′	− 96	121		5	−
3	23.3	22.6	26.65	12′	16′	+ 46	90	+28	18	−
4	24.8	23.3	26.35	3′	40′	+ 26	92	−14	19	−
5	23.1	22.6	25.75	5′	33′			+35	10	−
6	22.4	21.8	25.40	13′	25′	+ 13	91	−33	15	−
7	22.9	22.3	25.00		24′	−178	169	−22	8	+
8	22.0	21.6	24.90	10′	22′	+ 6	59	−13	14	−
9	23.2	22.3	24.60	8′	43′	− 52	276	+38	6	−
10	23.1	22.6	24.45	8′	27′	− 11	60	+41	16	−
11	22.6	21.7	24.40	7′	16′	− 83	13	+62	14	−
12	22.7	22.3	24.35	8′	20′	+ 26	92	−14	19	−
13	24.6	23.5	24.25	7′	20′	+ 27	97	+11	14	−
14	22.5	22.2	23.90	8′	24′	+ 8	75	+17	12	−
15	22.6	21.7	23.80	15′	48′	+ 2	100	+19	11	−
16	24.7	23.4	23.60	3′	40′	+ 26	92	−14	19	−
17	22.7	21.8	23.55	6′	26′	+ 24	85	−33	14	−
18	22.9	22.3	23.45	5′	24′	− 63	93	−22	8	−
19	23.4	22.6	23.05	7′	16′	+ 48	284	−74	19	−
20	21.7	21.6	22.75	8′	25′	+ 28	97	−42	12	−
21	23.4	22.6	22.70	24′	45′	− 3	102	+ 6	13	−
22	23.7	22.6	22.65	12′	24′	+ 2	19	−11	16	−
23	22.5	22.2	22.35	6′	21′	− 8	70	−13	16	−
24	22.7	21.8	22.05	7′	18′	+ 17	89	+17	16	−
25	22.4	22.3	21.95	3′	17′	+ 13	139	+32	17	−
26	22.4	21.8	21.90	5′	21′	+ 10	52	−30	11	−
27	22.6	21.8	21.60	9′	29′	− 14	115	− 9	10	−
28	22.8	21.8	20.95	7′	20′	+ 16	97	+16	13	−
29	22.6	21.8	20.90	6′	22′	+ 9	121	−30	13	−
30	22.8	21.8	20.65	5′	11′	+ 9	94	−29	19	−
31	22.6	21.7	20.65	15′	31′	− 3	131	+32	17	−
Mean	21.7 24.8	21.9 23.5	20.65 26.90	3′ 24′		+ 4.7	88 260	+0.1	13.5	97%

Experiment III. *Acmaea schrenckii* var. *concinna.*

The limpets used in this experiment were *Acmaea schrenckii* var.

concinna, which live in sea-water the larger part of the day, and is exposed in the air only when the lowest tide comes for about 2 or 3 hours. So I wished to know how *Acmaea shrenckii* var. *concinna* differs from *Acmaea dorsuosa*, in respect to tropism.

The same methods were used. It was found that *Acmaea schrenckii* var. *concinna* shows quite the reverse reaction from that of *Acmaea dorsuosa;* that is to say, it crawled downward in both cases, whether the head was placed up or down, swiftly creeping to the bottom of the tank, then turning to either right or left without stopping. The tracings taken from *Acmaea shrenckii* var. *concinna* are shown in Fig. 5 and the data for the same are shown in Table IX.

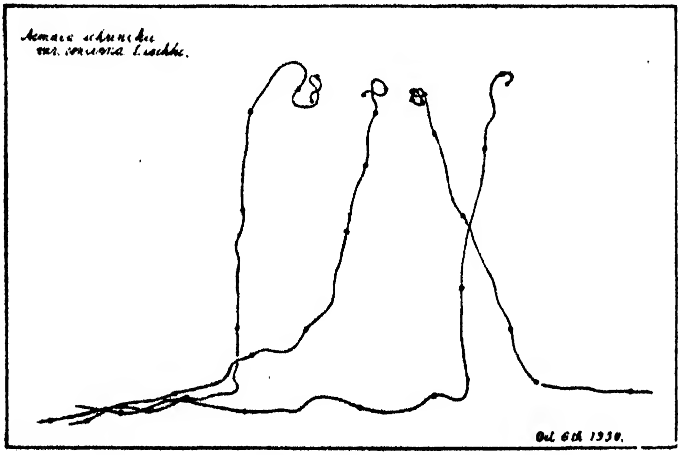

Fig. 5. Tracing the movement in Experiment III.

TABLE IX. Geotropism. Ex. III.

No.	Atmospheric temperature C°	Sea-water temperature C°	Shell length in m.m.	Time used to complete the circus movement	Time used to reach the bottom of the tank	Inclination angle of passage	Maximum velocity in mm. per minute	Geotropism.
1	22.6	22.4	19.10	1′	3′	+ 9	78	+
2	20.1	18.9	17.80	1′		+18	15	+
3	22.4	19.7	17.70	2′30″	6′	+ 4	34	+
4	22.5	20.9	16.90	1′	4′	+ 7	70	+
5	19.9	19.0	16.40	13′	22′	−34	30	+
6	20.0	18.8	16.40	1′		+ 6		+
7	21.0	19.5	16.40	1′	5′	−14	40	+

No.	Atmospheric temperature C°	Sea-water temperature C°	Shell length in mm.	Time used to complete the circus movement	Time used to reach the bottom of the tank	Inclination angle of passage	Maximum velocity in mm. per minute	Geotropism.
8	20.0	18.8	16.20	9′	14′	+ 5	35	+
9	22.4	19.7	15.70	2′		−25	25	+
10	21.0	19.5	15.40	3′	7′	−21	64	+
11	21.7	20.7	14.50	1′		+69	62	+
12	20.0	18.8	14.50	1′	3′	+27	82	+
13	21.0	19.5	14.40	1′		+55	15	+
14	20.1	18.9	14.10	30″	3′30″	+18	45	+
15	19.1	17.8	14.10	1′	4′	+ 7	53	+
16	21.7	20.7	13.90		5′	+26	56	+
17	21.7	20.7	13.70	1′	9′	+ 2	22	+
18	21.2	20.9	13.60	2′	13′	+35	32	+
19	21.0	19.5	13.60	30″	2′	+12	63	+
20	22.0	20.2	13.30	30″	4′	+13	50	+
21	22.0	20.2	13.20			+13	11	−
22	20.2	19.7	13.10	1′	14′	+12	20	+
23	21.0	19.5	13.00	1′	6′	+52	83	+
24	21.7	20.7	12.90			−19	8	−
25	19.1	17.8	12.90	3′	7′	−20	47	+
26	19.8	19.2	12.70	2′	5′	+27	43	−
27	19.8	19.2	12.60	2′		+53	15	−
28	19.1	17.8	12.50	1′30″	7′	+31	43	−
29	21.2	20.9	12.40	1′	11′	+10	35	−
30	20.0	18.8	12.40	1′		+53	36	−
31	20.0	18.8	12.30	1′	3	−34	86	−
32	19.1	17.8	12.30	2′30″	5′30″	+17	45	−
33	19.5	18.1	7.00	1′		− 3	13	−
Mean	19.1 22.6	17.8 22.4	19.10 7.00	0′30″ 5′		+13.5	42	94%

Discussion and Conclusion in regard to Geotropism.

I. We must consider whether the results shown by the above experiments can be interpreted as geotropism or as some other tropism. As for *Acmaea dorsuosa*, it seems as though its general behavior is more closely related to the chemotaxis to oxygen than to geotropism, but since this limpet creeps upward on a glass plate, inclined about 60 degrees, even in the air and hence does not creep any faster than that in the former experiment, towards an entrance of the fresh sea-water in the bottom of the glass tank, I think that the phenomena may safely be interpreted as related to gravity. G. BOHN ('05) says that, "The tendency in ascending or descending the rocks is to orient the body in the line of the greatest slope. When light and gravity are acting together upon the animal, its movement seems to be a

resultant of the two, but if the mollusk is made to move on a vertical plane, gravity thus exerting its maximal force, the influence of the light disappears all together; and if the animal is put in an upside-down position by further tipping of the surface, the sense of its phototropism is reversed; that is, it may be repelled instead of attracted by a dark screen".

II. As soon as *Acmaea dorsuosa* reached the water surface, some individuals stopped movement entirely, and some individuals continued creeping under the water surface, while still others soon crept above the boundary line. Those which stopped movement were 16 out of 61 individuals or 26.2%, while those which crept under the surface of the water were 10 individuals or 16.4%, and those which continued creeping beyond the water surface (without remarkable hesitation) were 14 individuals or 22.9%. Therefore, these individuals which hesitated excessively at the boundary face were 26 in all, or 42.6%. From the above it seem that the boundary line between the two different mediums affects the geotropism of *Acmaea dorsuosa* strongly. The fact that *Acmaea dorsuosa* shows negative geotropism while *Acmaea schrenckii* var. *concinna* shows positive geotropism, and again that the latter is much faster than the former, showing the ratio of their respective creeping velocity, 1 : 3, may be interpreted as the result of adaptation to their circumstances, namely, *A. schrenckii* var. *concinna* lives between the high and the low-water mark, thus exposing itself to more a dangerous life than the former species which sustains a less dangerous life in the air.

III. In comparing the inclination angles of their traces, we find that *A. dorsuosa* shows +0.1 degrees (deviation ..±41°), and *A. schrenckii* var. *concinna* shows +13.5° (deviation ..±45°), consequently, the intensity of perception of gravity's direction is almost the same in the both species. The mean inclination angle, +13.5°, observed from *Acmaea schrenckii* var. *concinna*, seems to show only the effect of light. As for the relation of temperature to geotropism, there appears to be no remarkable influence to geotropism between 18.0°C and 26.0°C.

The time required to complete the circus movement is for *Acmaea dorsuosa* about 8 minutes (deviation..3 to 15) and for *Acmaea schrenckii* var. *concinna*, about 1.5 minutes (deviation..30 seconds to 5

minutes). The ratio, 1 : 5.5, of the time of circus movement, is considerably different when compared with the ratio of creeping velocity, 1 : 3. This faster circus movement than the ordinary forward creeping movement in *Acmaea schrenckii* var. *concinna* may be due to the relative difference in intensity of perception of gravity.

2. Rheotaxis.

The species in which the rheotaxis has been examined are few. HERTER ('04) studied on *Nassa obsolete*, DEWITZ (quoted from Tabulae Biologicae IV, W. JUNK. Berlin 1927, p. 350) studied on Unioiden, and LESLIE B. AREY & W. J. CROZIER ('19) on Chiton.

So far I have tested this taxis on *Acmaea dorsuosa* only.

METHOD:

The method used in this experiment is very simple, namely, a piece of frosted glass plate (length 35 cm., breadth 25 cm.) is inclined about 7 or 8 degrees and sea-water is made to flow over the rough side of the plate. The volume of running water is at the rate of about 190 cc. per minute, through glass tubing of 8 mm.

In the following experiments, six limpets were placed in a line with intervals of 2 cm. between one another and then the water was turned on, and every ten minutes, I noted the positions as well as the direction of the movement.

Results of the experiment.

During the experiment, the temperature of the sea-water ranged between 8°C and 12°C. The limpets which were placed on the plate, began to crawl very slowly, compared with the experiment on geotropism, but gradually, they all reached the source of the current. Table X shows the results of the experiment.

In the table, 0 indicates a motionless state or where the tropisms were not obvious. +1 signifies that the limpet advanced toward the source from 0.5 cm. to 3 cm.; +2 signifies from 3 cm. to 10 cm.; +3 signifies from 10 cm. to 20 cm.; +4 signifies from 20 cm. to 30 cm.; and +5 signifies from 30 cm. to the source. The negative sign indicates locomotion in the opposite direction from the current source. Conveniently, if I express the strongest rheotaxic reaction or one which

TABLE X. Rheotaxis.

No.	Shell length in mm.	Experiment 1.		Experiment 2.		Experiment 3.		Rheotaxis in %	
		20 minutes after	1.5 hours after	20 minutes after	1.5 hours after	20 minutes after	1.5 hours after	20 minutes after	1.5 hours after
1	27.00	0	+1	+1	+1	+1	+1	+40	+ 60
2	26.80	0	−1	0	+1	—	—	0	± 0
3	25.30	0	+2	0	0	0	0	0	+ 35
4	25.20	+2	+4	−1	−2	+1	+2	+35	+ 35
5	24.95	−1	−1	+1	+2	0	0	0	+ 35
6	24.80	−1	+4	+1	−1	—	—	−60	+ 10
7	24.45	+1	+2	+1	+2	−1	−1	+20	+ 27
8	24.10	0	0	0	0	0	0	0	0
9	23.95	+3	+4	0	0	0	0	+27	+ 30
10	23.90	+1	+4	+2	+4	+1	+1	+63.3	+ 87
11	23.60	0	0	0	0	0	0	0	0
12	23.35	0	0	0	+1	0	0	0	+ 20
13	23.35	+1	+4	+1	+1	0	+1	+40	+ 70
14	23.05	0	0	0	+1	0	0	0	+ 20
15	22.70	+2	+2	0	0	0	0	+23.5	+ 23.5
16	22.55	+1	−2	+1	+1	0	−1	+40	− 23.5
17	22.35	+3	+4	—	—	—	—	+60	+ 90
18	22.00	+1	+1	+2	+3	+1	+1	+63.3	+ 67
19	22.00	+1	+3	0	0	0	0	+20	+ 27
20	21.75	0	+1	0	0	—	—	0	+ 30
21	21.70	+1	−1	+1	+3	+1	+4	+60	+ 77
22	21.70	+1	+4	—	—	—	—	+60	+ 90
23	21.60	0	0	0	+1	+1	+3	+20	+ 47
24	21.50	0	−2	+1	+2	0	0	+20	± 0
25	21.30	0	0	0	0	0	−1	0	− 20
26	21.25	+1	+1	+1	+1	+1	+2	+60	+ 63.3
27	21.20	+1	+1	+1	+3	0	+2	+40	+ 70
28	21.15	+1	+3	+2	+4	—	—	+65	+ 85
29	21.00	0	0	0	+2	+1	+2	+20	+ 47
30	20.65	0	+1	−1	−1	0	+1	−20	+ 20
31	20.60	+2	+5	—	—	—	—	+70	+100
32	20.55	+2	+3	—	—	—	—	+70	+ 80
33	20.20	0	+1	+1	−2	+1	+2	+40	+ 20
34	19.95	0	+3	+1	+2	0	+1	+20	+ 70
35	19.85	+1	+2	+2	−2	+1	+3	+63.3	+ 27
36	19.80	0	0	0	0	0	+1	0	+ 20
37	19.75	0	0	0	0	0	0	0	0
38	18.65	0	+3	0	+1	0	0	0	+ 50
39	18.30	0	0	0	+1	0	0	0	+ 20
Ranges	18.30–27.70	The distance traversed by limpets towards the current source or relative strength of rheotaxis.						+24.2	+ 37.8
		No. of cases which showed positive rheotaxis.						92%	94%

reached the current source as 100%, then the values shown in the table become: 1=60%, 2=30%, 3=80%, 4=90%, 5=100%.

Discussion and Conclusion to Rheotaxis.

Since the limpets used were exposed in the air more than one day before the test was made, one may interpret the movement towards the source of the water current as a striving for a free supply of water in the subnuchal cavity or in other parts, or as the taxis to oxygen. But, as has been previously mentiond, the limpet turns in the direction of the current of tank water of the same oxygen content made with a squirt. This fact seems to prove that it is more proper to consider that the limpets were forced to move mainly by rheotaxis, especially when we have in mind that the limpets Nos. 4, 10, 27 and 30, respectively, crept to the source of the current and remained there, exposing themselves to the tapping of the water.

In Table X, are given only the results of 20 minutes and 1.5 hours after the experimentation, but there were a few individuals which began to creep after 1.5 hours and I have gathered these cases in Table XI. But it is not clear why these individuals differ from these shown in Table X. How the phenomena of rheotaxis is modified by exposing the limpets to different conditions previous to the experimentation, is not yet clear.

TABLE XI. Rheotaxis 2.

No.	20 minutes after	1.5 hours after	3–4 hours after
21	+1	−1	+2
27	0	+2	+4
30	0	+1	+5
36	0	0	+1
37	0	0	+2
37	+1	+1	+4

It is interesting to note that the phenomenon of rheotaxis appears to be readily modifiable according to the former conditions to which these were exposed. As one example I have seen that all limpets, tested immediately after being taken from water in which they had stayed more than one day, showed negative rheotaxis.

SUMMARY.

I. Formation of Colony.

1. In Mutsu Bay, from about the 10th of April to about the 10th of September, *Acmaea dorsuosa* forms a group on the rock, over the high-water mark.

2. The limpets, in the group, are seated on the rock, head side down.

3. From about the middle of September to about March of the next year, the limpet does not form groups.

II. Habits.

4. The mode of locomotion of *Acmaea dorsuosa* and *Acmaea schrenckii* var. *concinna* belongs to subtype Ditaxic movement of the Direct type; they can do both forward and backward locomotion.

5. The maximum velocity of locomotion is about 2.8 centimetres per minute in *Acmaea dorsuosa*, and about 8.6 centimetres per minute in *Acmaea schrenckii* var. *concinna*.

6. In the water tank, the larger *Acmaea dorsuosa* (shell length more than 1.5 cm.) shows movement every night, but in nature, it moves only once in about 12 days at evening or at night.

7. Smaller *Acmaea dorsuosa* (shell length less than 1.3 cm.) move even in the day time in the laboratory as well as in nature when the rocks are washed with the waves.

8. Larger limpets have homes but they do not appear to be permanent.

9. Smaller limpets appear to begin to climb up on the rocks in the air from the water when the shell length reaches from 4 mm. to 12.5 mm.

10. The sucking power of *Acmaea dorsuosa* is equivalent to about 373 grams or more per 1 cm. square of it's foot surface.

11. *Acmaea dorsuosa*, placed on a flat plate, shows no righting reactions.

12. *Acmaea dorsuosa* has stock-water in the subnuchal cavity and between the shell and the mantle; and its amount in a shell length of about 28.60 mm. to 19.85 mm. may be expressed by the formula, $y=8x^3+19.0$.

III. Tropisms.

13. *Acmaea dorsuosa* exhibits negative geotropism, while in *Acmaea schrenckii* var. *concinna* it is positive.

14. The boundary line between water and air strongly affects the geotropic reaction in *Acmaea dorsuosa.*

15. *Acmaea dorsuosa* changes its body direction by 360° in about 3 to 8 minutes, and *Acmaea schrenckii* var. *concinna*, in about 30 seconds to 1 minute.

16. *Acmaea dorsuosa* exhibits positive rheotaxis, but it is changeable according to the former conditions to which it was exposed.

17. Most of the limpets display rheotaxis promptly, but it appears in some after 3 or 4 hours.

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EXPLANATION OF PLATE.

PLATE XII.

Fig. 1. The colony of the limpets at summer season. Reduced to one third of the normal shell size. (photographed on August 10, 1930.)

Fig. 2. Scattered state of the limpets at autumn season. The black lined region is the same rock as the one in Fig. 1. Reduced to one third of the normal shell size. (photographed on September 25, 1930).

Fig. 3. The rock where the limpets form colonies. The white lined square is the same region as that in Fig. 1 and 2, and the length of the scale is 30 cms. (photographed on May 29, 1931, at the time of low-tide.)

Fig. 1.

Fig. 2.

Fig. 3.

ABE: photo.

N. ABE: Ecological Observations on *Acmaea*.

Study of *Euryale ferox* SALISB. VII. Change of Catalase and Germination Percent during the After-ripening of the Seeds.

By

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INTRODUCTION.

In 1930, the writer published a paper[10] concerning the phenomenon of delayed germination in the physiology of the seeds of *Euryale ferox*, noticed the fact that the content of reducing sugar increases in the course of after-ripening, and suggested that other substances in the seed as well may probably be subjected to some change during the same process. The study along this line of the problem has since been continued up to this day. However, the circumstance that the embryo, the essential part of the seed where the primary change is expected to take place, occupies an exceedingly minute part* in the seed of *Euryale* necessarily made the study rather difficult. It is not at all a facile task to collect a number of seeds in the field and to prepare embryos out of them in sufficient quantity for the material of investigation. Owing to such inconvenience, the knowledge concerning this hitherto attained is quite limited. As part of this, the knowledge about the change of catalase activity in the course of the after-ripening as compared with the change in germinability is established to such a point that some peculiarities were noticed which diverge from any similar case ever reported with other seeds. Now, as the writer is going to leave here for a few years, he takes this opportunity to give herewith a brief report with respect to the point just mentioned.

*Only 0.71% of the fresh weight of the whole seed; c. f. OKADA, 1930, p. 55.

MATERIALS AND METHOD OF THE STUDY

The seeds of *Euryale ferox* SALISB., employed in the present study, were all the product of Zyûnityôgata*, collected on Oct. 15, 1929. After sampling in the said locality, the fruits were sent immediately to the laboratory where they were put into large glass vessels filled with water, and kept until the pulp of the fruits was disintegrated and the seeds within were set free in the water. This took some few weeks. The seeds thus delivered were then gathered, separated from fruit-debris and arylar coverings, and then stratified in mud in shallow water-tight pots of porcelain, some 70 cm. wide and 30 cm. deep, which were kept always full of water so that the mud with the seeds was always under water. These pots were put in an "Osakamuro", a kind of shelter for those garden plants which are sensitive to frost. There is no heating device in the Osakamuro except electric lamps, lit at night during the winter months. Hence there is no remarkable difference in temperature beyond some degree of amelioration in the interior of the Osakamuro as compared with field condition. The record of monthly averages of daily maxima and minima of air temperature in the Osakumuro from June 1930 to May 1931 is shown in Table 1.

TABLE 1.

Record of monthly averages of daily maxima and minima of temperature (1930 to 1931)

		1930 June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1931 Jan.	Feb.	Mar.	Apr.	May
Osakamuro	Maximum	24.9	27.4	31.2	27.2	22.8	13.7	9.8	7.9	5.3	11.1	15.0	20.0
	Minimum	15.5	21.6	23.4	16.5	10.7	4.7	2.5	-0.9	-1.6	1.1	5.3	8.8
	Difference	9.4	5.8	7.8	10.7	11.1	9.0	7.3	8.8	6.9	10.0	9.7	11.2
Laboratory room	Maximum	23.5	25.9	31.1	23.1	17.6	16.7	19.2	17.2	17.8	15.1	18.6	17.6
	Minimum	20.0	22.8	28.0	20.6	14.7	11.0	10.8	7.9	8.2	11.3	12.6	15.2
	Difference	3.5	3.1	3.1	2.5	2.9	5.7	8.4	9.3	9.6	3.8	6.0	2.4

*c. f. OKADA, 1930. p. 50.

As for the temperature of the actual stratification point of the seeds in the vessel, detailed consideration will be made some day in connection with other problems of the *Euryale* seed and we will restrict the matter to the fact that the variation of temperature in the pot is still more ameliorated than that of the air. It may suffice here to mention that the seeds themselves or the water directly surrounding them were never observed to be frozen, and such conditions seem to be probably like those in the natural habitat of this plant.

The seeds thus stratified were subjected to study every six months or thereabouts. They were picked up out of the mud, cleansed of the mud, coated off, and the internal part of the seed was then divided into two portions, namely, embryo plus endosperm, and perisperm. As the endosperm of the *Euryale* seed is exceedingly thin, this part was not studied separately. The preparation thus obtained was put immediately into a weighing bottle, counterpoised, and the fresh weight being recorded, was subjected to the catalase determination by means of APPLEMAN's apparatus.[1,2] Fifty embryos (plus endosperm) or 2 to 3 g. of perisperm were employed in each determination. These were ground to a mash in a small glass mortar with excess of $CaCO_3$ powder and washed into the shaking bottle with 10 cc. of distilled water. Five cc. of hydrogen peroxide (3.4–3.8%) which was neutralized beforehand with NaOH solution was applied. Owing to the deficiency in the sample, it was not undertaken to test with various proportions of hydrogen peroxide with respect to the quantity of the material, so that some of the results in the present paper are open to some correction, and the writer hopes to rectify them in the future. The test was performed at 20°C with shaking frequency of about 80 per minute. The volume of the evolved oxygen was calculated under normal temperature and pressure, and per one g. of the fresh weight of the material. In the case of the embryo, triplicate tests were run and the average was reckoned from them. As for the perisperm, only a single determination was made each time. At first, it was questioned whether we can standardize the degree of grinding. But as the character of the material was almost similar through the period of investigation, it was found not difficult to get a comparable state of homogeneity by fixing the minimal limit in the time of the grinding. On the other hand, it was preliminarily tried to compare this with

another method, namely, pressing the material through a fine wire sieve (36 meshes in 1 cm.) instead of grinding in a mortar. It was proved, however, that the development of oxygen was far more vigorous in the grinding method than in the other. From these circumstances, the grinding method was employed throughout the whole study.

At the same period of the catalase study, the germination percent of the seeds was tested. 100 seeds were put into a large ERLENMEYER flask of 1000 cc. capacity, filled with water and stoppered, and were kept incubated at a constant temperature of 25°C. The test was run also in triplicate, that is, 300 seeds in total were employed each time. The germinated seeds were counted every week. As the full germination percent was to be attained in 2 or 3 weeks and subsequent germination was almost negligible if any, the count at the end of 4 to 5 weeks can be safely taken to be the full germination percent. In the accompanying table, this value is given as germination percent.

To get some comparative knowledge about the catalase activity under different storage conditions, some seeds of the same lot were kept under different conditions. They were immersed in tap water in a glass jar instead of being stored in water-saturated mud in porcelain pots, and the glass jar was kept in the laboratory room, not in the Osakamuro. The temperature of the laboratory room was somewhat different from that of the Osakamuro, and especially so in the winter months, as is shown in Table 1.

RESULT AND DISCUSSION

For the sake of brevity, the result of the measurement is arranged in the accompanying table.

From these results, the following features can be observed concerning the *Euryale* seeds.

Firstly, the distribution of catalase is always far more dense in embryo plus endosperm than in perisperm. The distribution among the embryo and endosperm was not studied, as already mentioned, but it is probable that the embryo itself is the main site of the catalase. According to CROCKER and HARRINGTON,[4] the catalase in Stoner wheat and in Sudan grass is mainly found in the embryo

TABLE 2.

Change of catalase activity and germination percent of the seed.

Date of measurement		Nov. 13, 1929		May 2, 1930		Dec. 18, 1930		Mar. 23, 1931		*Apr. 18, 1931	
Age of the seeds after harvest		about 1 month		about 6½ months		about 14 months		about 17 months		about 18 months	
Germination percent		1.3%		34.7%		13.7%		94%		0%	
Part of seed		embr. & endo.	peri.	embr. & endo.	peri.	embr. & endo.	peri.	embr. & endo.	peri.	** embr. & endo.	peri.
O_2 evolved (in cc.) per 1 g. of the material (fresh weight).	1 minute	3.6	0.7	1.9	0.42	1.6	0.37	0.6	0.03	2.1	0.10
	2 ,,	5.8	0.9	4.3	0.59	2.1	0.37	1.1	0.06	2.1	0.11
	3 ,,	9.5	1.2	7.5	0.59	2.6	0.37	1.6	0.12	2.1	0.11
	5 ,,	17.4	1.5	12.0	0.59	4.2	0.42	2.8	0.19	2.1	0.13
	10 ,,	34.2	1.9	21.7	0.59	8.0	0.55	5.3	0.25	2.3	0.13

*This column pertains to the seeds stored in the laboratory room, all the other columns being of the seeds in the Osakamuro.

**Owing to the deficiency in the material, catalase test in this column was made with preparations from 28 seeds, and with a single determination only.

(1918, p. 146, 147). GRAČANIN[8] also states that catalase is demonstrated chiefly in the embryos in such dicotyledonous seeds as *Pisum*, *Lupinus*, *Sinapis* and *Citrus*. As for *Zea mays*, he does not distinguish embryo from endosperm, yet he confirms the fact that these two parts combined are far more rich in catalase than testa. The result with *Euryale* seed seems not to be materially different from those of the former authors.

Secondly, the change of germination percent and catalase activity will be discussed. The change of germination percent during the stratification period is not smooth at all. In general, the germination percent of *Euryale* seeds is exceedingly low at or directly after the time of harvest. It is not a rare occurrence that the germination of freshly harvested *Euryale* seeds from Zyûnityôgata is nil. In the present case, some seeds were observed to begin sprouting, yet the

percent is quite low as is shown in the table. In the next spring, i. e., some 6 to 7 months after the harvest, the germination percent became somewhat improved, and in the autumn of the same year, it was again reduced. In the second spring, i. e., some one and half years after the harvest, it was improved again almost to its full vigour. In the meantime, the catalase activity did not remain stationary at all, but was also destined to suffer a certain change. In this case, however, the tendency of the change was not irregular as it was with the germination percent. During the course of after-ripening, the catalase activity was constantly decreasing both in embryo and in perisperm, and it was never observed to vary as in the case of germination, now increasing and then decreasing. The reduction in the catalase activity was demonstrated not only with the materials in the Osakamuro, but also with those kept in the laboratory. From these facts, it seems probable that such reduction in the catalase activity during the aging process is not a phenomenon limited to some special condition, but is of more fundamental significance.

To sum up, so far as the *Euryale* seed is concerned, the germination percent and the catalase activity have no positive correlation at all in their tendency of change. Nor is any negative one demonstrated. The two properties behave almost independently of one another.

In the papers hitherto published concerning the after-ripening of seeds, it has often been reported that the germinability and the catalase activity increase hand in hand. *Crataegus*[7,13], *Tilia*[12], sugar maple[9], *Cornus* and *Sambucus*[5] are some of these examples. Parallelism in decrement is also known with some plants, e. g., in river maple[9] and in wheat[11]. Recently, DENNY and others reported that in their forcing experiment with potato tubers, increment of catalase was noticed.[6] All these facts seem to favor the view that the catalase activity is positively correlated with the capacity of germination. On the other hand, however, data of the negative sense were also observed in some seeds. According to CROCKER and HARRINGTON[4], the seeds of Johnson grass and *Amaranthus* are improved in their germination percent by aging, while the catalase activity is reduced or, at least, not increased. This phenomenon is interpreted by them to mean that the dormancy of these seeds is mainly due to their coat character, so that the apparent increase in germination may take place independently of the

properties of the embryo, say, the catalase activity.

Now, the case of *Euryale* seeds treated in the present paper is different from those examples in the point that the dormancy here is of embryonic character and the after-ripening process means a time-requiring change in the embryo*, and yet, there is no positive correlation between the germination power and the catalase activity. It is not simple to compromise these discrepancies. If the idea is to be adopted that catalase represents the vital activity, one of the explanations for the present case is that the reduction in the vitality to a certain extent may sometimes serve as a stimulus to awake dormant life. Such a view is proposed by COVILLE[3] in his study with dormant branches exposed to coldness. This is, however, but a mere hypothesis in the case of *Euryale* seeds, and moreover, the data of the 5th column of Table 2 is not explicable with this view. So a safe explanation is still to be discovered.

SUMMARY

1. Distribution of catalase in the *Euryale* seed is far more dense in the embryo than in the perisperm.
2. During the period of stratification, the change in the germination percent of the seed is not regular; both improvement and reduction can take place.
3. Catalase activity is constantly decreasing during the same period.
4. No direct correlation was demonstrated between the germination percent and the catalase activity.

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*c. f. OKADA, 1930, pp. 100–101.

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P. S.

After the completion of the manuscript, the January issue of "Plant Physiology" has come to hand, in which is contained a paper* chiefly dealing with phenolase activity in relation to seed viability. Besides phenolase, there is also given, in this paper, a short reference to catalase activity as well. According to the record in Table V** in this paper, catalase activity and germination percent are always decreasing hand in hand with the age of the seed both in Arlington white spine cucumber and in Michigan amber wheat, an analogous data to the river maple of JONES[9] and the wheat of RHINE[11].

*DAVIS, W. C., Phenolase Activity in Relation to Seed Viability. Plant Physiol., Vol. 6, pp. 127–138, 1931.

**The numerals in the 5th column of this table must be arranged in reverse order.

On the Physiological Axial Gradients[1] of Chaetopod Annelids.

II. Axial Gradients of Oxidizable Substance in Earthworms, as Determined by the Manoilov Reaction.

BY

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INTRODUCTION.

Since MANOILOV's work on sexual chemical differences was published in 1922–1923, the validity of his conclusions and the physiological and chemical interpretation of the results obtained have been studied with considerable interest by many authors. Among these workers, GALWIALO and his associates (1926) have presented exact data which essentially clear up the chemical mechanism of this reaction and show that, in general, only these substances which are more easily oxidized than the dye used protect the dye solution from oxidation by potassium permanganate in acid medium and so prevent the decoloration of the dye solution in the test. According to these conclusions, the fact that the Manoilov reaction may serve as a chemical test for sexual differentiation apparently results only from the difference in content of easily oxidizable substances in the blood or tissues in the different sexes. As regards other lines of evidence, existence of differences in amount of oxidizable substances or in intensity of oxidation-reduction potentials between male and female tissues have been shown in many species of organisms[2]. It is evident that, as GALWIALO and his coworkers (1926), ALSTERBERG and HAKANSSON (1926) and SCHRATZ (1926) have

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1) For discussion and bibliography of the *gradient theory* the reader is referred to CHILD's "Physiological Foundation of Behavior" (1924), Chapters VII–X and his general paper "Physiological Gradients" in Protoplasma, v, pp. 447–476, (1928).

2) DEWITZ (1908, 1912); JOYET-LAVERGNE (1928) and literature cited there; TADOKORO (1930), etc.

have clearly demonstrated, the Manoilov reaction is not a specific test for sex alone, but, correctly speaking, a general and quantitative reaction for the total amount of those substances which protect the dye used from oxidation and decoloration by $KMnO_4$. On the basis of this conclusion I attemted to employ this reaction as a quantitative test for oxidizable substances in tissue extracts and to apply it to investigation of the axial gradients in some of the larger forms of annelid worms.

In various species of small organisms both in animals and plants, Child (1919 a, b, 1921, 1925, 1926, 1927) and Galigher (1921) observed marked axial differentials in rate of reduction of permanganate, as indicated by appearance or change of color of oxides formed in tissues. And Child (1915, 1926), and Child and Deviney (1925) also found gradients of reduction of methylene blue and brilliant cresyl blue, and gradients of indophenol blue reaction in various protozoa, embryos and other small forms. The methods adopted by these authors can be applied to the individual as a whole without any mechanical operations and the results obtained can be easily observed in the living organisms under the microscope or often with the naked eye. While these methods are of value for smaller, more or less transparent forms, they cannot be applied to the larger organisms, especially those with thick or hard cuticular layers, which are not easily permeable to the dye, and those having dark colored pigment in the tissues, which makes it impossible to observe the color gradations. Moreover, with these methods it is difficult or impossible to obtain quantitative data.

In the case of the Manoilov reaction, the determination cannot be made on the living, uninjured organism. The body of the worm must be separated into pieces and ground completely for the purpose of tissue extraction. The use of the Manoilov reaction avoids the disadvantages of the methods mentioned above but the gradients of oxidizable substance observed by this method of course concern only the water-extractable oxidizable substances.

TECHNIQUE.

Tissues were thoroughly ground in a mortar with sand, extracted with distilled water, and stood in an ice-box over night (approximately

for fifteen hours). The temperature in the ice-box was 6° to 10°C. For extraction, 10 cc. of distilled water were added for each gram of tissues, that is, 10 per cent aqueous extracts were prepared. After centrifuging for twenty minutes at 2,000 revolutions per minute, the supernatant fluids alone used. These were filtered and preserved in the ice-box until the Manoilov reagents were added.

For the quantitative analysis I have adopted the principle of POLONOWSKI's simplified modification of the Manoilov method (1929). The procedure is as follows: To 3 cc. of tissue extract in a small vial, 1 cc. of 0.05 per cent solution of dye (in 75 per cent ethyl alcohol) and 1 cc. of normal hydrochloric acid were added and completely mixed. The acidity of the mixture is almost constant, the concentration of hydrochloric acid in the mixture being one-fifth normal at the beginning of the reaction. Next one-tenth normal solution of potassium permanganate was added from a micro-burette, 0.05 cc. at a time, and the mixture was gently stirred, then allowed to stand for a few seconds after each addition of permanganate, in order to permit determination of the final color. The addition of permanganate was continued until the color of the mixture became yellow. Then, 0.5 cc. of 2 per cent solution of thiosinamine was added in order to prevent further oxidation by the permanganate and the oxides which have resulted from partial reduction. The dyes employed were the alcoholic solutions of light green, dahlia and fuchsin. These three dyes give somewhat different end points because the permanganate equivalents for decoloration are different.

In this method, there were two difficulties as regards the exact determination of the end point of the reaction. First, it is difficult, before adding the thiosinamine solution, to select as end point a particular shade of the yellow color which appears as the end point is approached. Consequently the titration by permanganate alone is not sufficiently exact for the purpose of this work. Second, since the color change or fading in tone of the dye solution takes place very gradually with increase in amount of permanganate added, several determinations are desirable in each case. In order to overcome as far as possible the first difficulty, after observing the end color of the reaction in the first titration, several determination were made with similar samples of tissue extract and in later determinations 0.05 cc.

more or 0.05 cc. less of permanganate than in the first determination was added. In this manner I prepared six or seven grades of color in vials, and compared these color grades with each other and with the color standard for each dye described below. To avoid the second difficulty, I selected as the standard color tone in this investigation a comparatively distinct shade which appears just before complete decoloration of the dye. For obtaining standard color tones for each dye a solution consisting of 1 cc. of 0.05 per cent solution of the dye and 3 cc. of distilled water was used. The minimal quantities of permanganate necessary to give the standard colors were as follows:

Dye	N/10 $KMnO_4$ in cc.	Tone
Light Green	0.09, practically 0.10	Colorless
Dahlia	0.35	Light Yellow
Fuchsin	0.55	Light Yellow

For the purpose of comparison the color tones obtained when the amount of permanganate added as less by 0.05 cc. than the above mentioned amounts are given below.

Dye	N/10 $KMnO_4$ in cc.	Tone
Light Green	0.05	Green
Dahlia	0.30	Brown
Fuchsin	0.50	Brown

These values are somewhat different from those obtained by GALWIALO and his coworkers (1926); but this discrepancy is probably due to the different amounts and different concentrations of reagents, especially those of dye and hydrochloric acid used here and the color tones adopted as standards for the end point of the reaction may be also different from theirs. And finally for the comparison of the color grades, it is important to note that small vials with as nearly as possible the same diameter must be selected (in this experiment vials 1.5 cm. in diameter were employed). A white background was used at a distance of 1 cm. behind the vials to be compared. Since the

color tones resulting from the Manoilov reaction fade rapidly, it is necessary to prepare color standards or to make relatively permanent standards as RIDDLE and REINHART did (1928).

The data presented later are the differences in amount of permanganate which are necessary to oxidize the solution of dye (diluted with 3 cc. of distilled water) alone from the amounts necessary for the mixture of dye and tissue extract. In other words the data give the net amounts of permanganate for tissue extracts alone with the use of different dye solutions.

In the original method as described by MANOILOV (1922–1923; third modification named by him in his work, 1924), papayotin solution was used in addition to the above mentioned reagents and such special protein has sometimes been regarded as a more or less important feature of this reaction. According to FALK and LORBERBLATT (1926), the addition of the papayotin solution in the original Manoilov reaction appears to provide the protein necessary to enhance the disparity in differentiation between sexes. However, PERKINS (1927) reported that he failed to confirm these conclusions. Moreover GALWIALO and his coworkers (1926), ALSTERBERG and HAKANSSON (1926) and SCHRATZ (1926) also pointed out that any protein materials added as reagent were not essential to this reaction. And the protein substances contained in the solution to be tested are the most important substances in the reaction. This fact has already been well shown in the list of substances described by GALWIALO and his coworkers (1926), which protect the dye from oxidation and decoloration in different degrees, and in the work of SCHMIDT and PERWOSSKAJA (1926) on the relation between the content of protein substances and the Manoilov reaction in blood sera from different sexes. Therefore, the addition of papayotin or other protein materials seems to be not only unnecessary, but disadvantageous, at least in the case of applying this reaction as a test for oxidizable substance. For this reason the papayotin solution was omitted from the reagents in this investigation.

Most workers with this reaction have applied the reagents in the same order as in the original Manoilov method, the hydrochloric acid being added after addition of permanganate. But, as mentioned above, in this work, the hydrochloric acid was added before the permanganate solution. As POLONOWSKI has insisted, this modification in the order

of addition of reagents seems to be necessary, since with this procedure the oxidation by permanganate takes place in acid medium from the beginning of the reaction. Moreover, from the color tones of the oxidized dye in acid medium, the amount of permanganate necessary for the oxidation can be roughly estimated. Such estimation is convenient, particularly for such cases as this in which a large amount of sample can not be employed, but it is impossible, if the hydrochloric acid be added after the addition of permanganate.

In connection with the technique of the Manoilov reaction, RIDDLE and REINHART (1928) have recently devised a colorimetric quantitative method, using a semipermanent color standard series which was made from a series of dilutions of nicotine and the ordinary Manoilov reagents. They compared the color tones obtained by addition of constant amounts of potassium permanganate and other reagents to the tissue extract with those of the standard series. This method is doubtless more simple and more convenient, but unfortunately I have been unable to prepare the color standards devised by them. In my attempts, the color standards did not retain their tone and intensity

TABLE I.

Data of the Manoilov Reaction in Various Tissues of Ring Dove (RIDDLE and REINHART) and Rabbit. Three CC. of Tissue Extract Used with Dahlia as Indicator.

Material	Ring Dove, in Color Grades (1–14)			Rabbit, N/10 $KMnO_4$ in cc.
Sex	Male	Female	Average for Both Sexes	Female
Liver	4.5	4.9	4.7	2.11
Kidney	5.0	5.35	5.2	1.60
M. gastrocnemius	11.5	11.4	11.5	0.51
Heart	11.55	11.6	11.6	0.49
Gizzard	—	14.0	14.0	—
Stomach	—	—	—	0.47

Data given in the second to fourth columns are those of RIDDLE and REINHART (1928), p. 518, Table I. In these data, the smaller numbers correspond to deeper colors, the larger to progressively lighter color. Data in the last column are from Table XI, on page 457 in this paper.

but underwent change within two or three days after preparation, instead of retaining them for several months as should be the case according to RIDDLE and REINHART. This failure may have resulted from some oversight in the procedure, which has not yet been discovered. However, as shown in Table I, their observations on the various tissues of the ring dove correspond, in general, with mine on rabbit tissues.

In general, the extract which required the greater amount of permanganate for decoloration of the mixture of dye and tissue extract displayed the darker color tone when a constant amount of permanganate was added.

EXPERIMENTAL DATA.

For the material, I have employed two species of earthworms, *Pheretima hilgendorfi* (MICHAELSEN) and *Allolobophora foetida* (SAVIGNY). The specimens which served as material for this investigation were all of adult form and in good condition without any injury and without even any trace of regeneration. And in both species the body wall alone was tested, the alimentary tract being removed before grinding the tissues.

1. *Pheretima hilgendorfi* (MICHAELSEN)

The worms were collected in the vicinity of Sapporo, Hokkaido, and examined at the Asamushi Marine Biological Station, Aomori-Ken in the summer of 1930. I have selected only those forms which have two patches or capsulogenous glands on the ventral side of preclitellar region (segments VIII and IX) and no prostates. In my collections, these forms of this species were more abundant than those having other external morphological features[1]. The body of the worm was

[1] According to YAMAGUCHI (1930), among the various forms of *Pheretima hilgendorfi* living in the vicinity of Sapporo, the form with a patch on segment VIII alone exceeded other forms in number (602/1010), while the form with two patches on segments VIII and IX was much less abundant (258/1010). But in my collection in summer of 1926 from various localities in Yamahana, on the southern outskirts of the city of Sapporo, where the worms employed for this investigation were collected, this species cosisted mostly of the form having patches on segments VIII and IX (55/96) and the form with one patch on segment VIII alone was less common (15/96). In my other collections from other localities in the vicinity of Sapporo, especially from the northern parts of the city, most specimens had only one patch on segment VIII.

dissected into seven parts, namely preclitellar part (*AB*), clitellum (*C*), and five equally divided postclitellar parts (*D*, *E*, *F*, *G* and *H*). Table II shows the axial gradient of the Manoilov reaction in ***Pheretima hilgendorfi***, with dahlia solution as indicator. Thirty worms were used for each test.

TABLE II.

Net Quantities (in CC.) of N/10 Potassium Permanganate Required for 3 CC. of 10 Per Cent Aqueous Extracts of *Pheretima* Tissues, with Dahlia as Indicator.

No. of Test	*AB*	*C*	*D*	*E*	*F*	*G*	*H*
1	0.85	0.80	0.75	0.65	0.70	0.65	0.85
2	0.95	0.90	0.80	0.65	0.60	0.65	0.65
3	1.00	0.90	0.65	0.70	0.60	0.60	0.65
4	1.05	0.75	0.65	0.70	0.65	0.60	0.80
5	1.15	1.00	0.65	0.55	0.45	0.50	0.60
Average	**1.00**	**0.87**	**0.70**	**0.65**	**0.60**	**0.60**	**0.71**

2. *Allolobophora foetida* (SAVIGNY)

The worms were collected from the stock farm near the Biological Institute of the university at Sendai in early spring 1931.

TABLE III.

Net Quantities (in CC.) of N/10 Potassium Permanganate Required for 3 CC. of 10 Per Cent Aqueous Extracts of *Allolobophora* Tissues with Light Green as Indicator.

No. of Test	*A*	M_1	M_2	*P*
1	0.85	0.60	0.90	0.95
2	0.95	0.60	0.75	0.95
3	1.00	0.80	0.55	0.80
4	1.05	0.85	0.70	0.90
5	1.20	0.85	0.80	0.90
Average	**1.01**	**0.72**	**0.74**	**0.80**

(1) Antero-posterior Gradient.

The body of worm was dissected into four parts, namely preclitellar part (A) and three equally divided postclitellar parts including clitellar region (M_1, M_2 and P). For each test one hundred worms were employed. Table III shows the results obtained with light green as indicator, Table IV those with dahlia and Table V those with fuchsin.

TABLE IV.

Net Quantities (in CC.) of N/10 Potassium Permanganate Required for 3 CC. of 10 Per Cent Aqueous Extracts of *Allolobophora* Tissues with Dahlia as Indicator.

No. of Test	A	M_1	M_2	P
6	1.25	1.15	0.95	1.15
7	1.30	1.25	0.95	1.05
8	1.40	1.05	1.25	1.40
9	1.40	1.10	1.10	1.20
10	1.45	1.15	1.10	1.30
Average	**1.36**	**1.14**	**1.07**	**1.22**

TABLE V.

Net Quantities (in CC.) of N/10 Potassium Permanganate Required for 3 CC. of 10 Per Cent Aqueous Extracts of *Allolobophora* Tissues with Fuchsin as Indicator.

No. of Test	A	M_1	M_2	P
11	1.45	1.00	1.20	1.40
12	1.65	1.25	1.20	1.40
13	1.65	1.30	1.05	1.15
14	1.70	1.45	1.40	1.65
15	1.75	1.25	1.25	1.45
Average	**1.64**	**1.25**	**1.22**	**1.41**

(2) Dorso-ventral Gradient.

The body of the worm was divided into two parts, dorsal and ventral. I have employed sixty worms for each test. Table VI, Table

VII and Table VIII show respectively the results with light green, dahlia and fuchsin as indicator.

TABLE VI.

Net Quantities (in CC.) of N/10 Potassium Permanganate for 3 CC. of 10 Per Cent Aqueous Extracts of *Allolobophora* Tissues with Light Green as Indicator.

No. of Test	Dorsal	Ventral	Differ.
1	1.00	0.70	0.30
2	1.10	0.75	0.35
3	1.15	0.65	0.50
4	1.15	0.85	0.30
5	1.20	0.85	0.35
Average	**1.12**	**0.76**	**0.37**

TABLE VII.

Net Quantities (in CC.) of N/10 Potassium Permanganate for 3 CC. of 10 Per Cent Aqueous Extracts of *Allolobophora* Tissues with Dahlia as Indicator.

No. of Test	Dorsal	Ventral	Differ.
6	1.25	1.05	0.20
7	1.40	1.20	0.20
8	1.45	1.10	0.35
9	1.50	1.05	0.45
10	1.55	1.10	0.45
Average	**1.43**	**1.10**	**0.33**

As the foregoing data show, the amount of potassium permanganate which is necessary to decolorize the colored extract of earthworm's tissues is different according to the different part of the body of the worm. In both species the amount of potassium permanganate required is most at the anterior end and decreases toward the middle, but again increases posteriorly (cf. Figure 1 and Figure 2). And the

TABLE VIII.

Net Quantities (in CC.) of N/10 Potassium Permanganate for 3 CC. of 10 Per Cent Aqueous Extracts of *Allolobophora* Tissues with Fuchsin as Indicator.

No. of Test	Dorsal	Ventral	Differ.
11	1.45	1.15	0.30
12	1.55	1.10	0.45
13	1.65	1.10	0.65
14	1.70	1.15	0.55
15	1.80	1.20	0.60
Average	**1.63**	**1.12**	**0.51**

dorsal wall of the body in *Allolobophora foetida* always needs a much larger amount of permanganate for decoloration than the ventral, no matter what dye is used (cf. Figure 3).

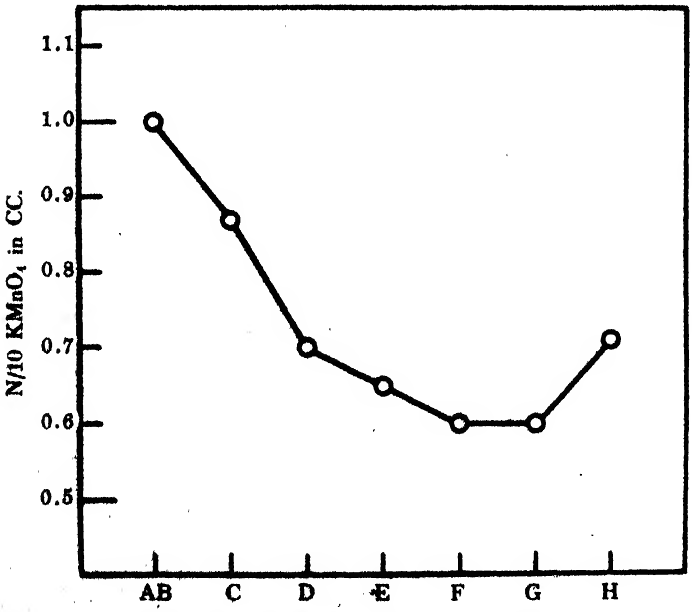

Fig. 1. Graph showing the gradient of oxidizable substance as determined by the Manoilov reaction in *Pheretima hilgendorfi*.

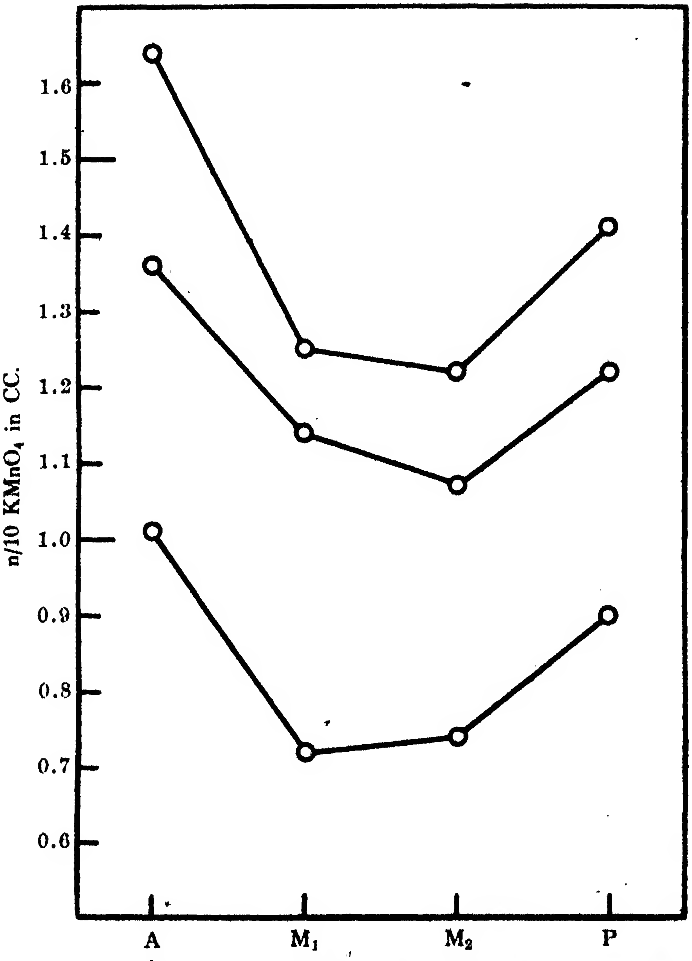

Fig. 2. Graphs showing the antero-posterior gradients of oxidiziable substance as determined by the Manoilov reaction in *Allolobophora foetida*. Upper curve from data with fuchsin as indicator, middle curve from data with dahlia and lower curve from data with light green.

COMPARATIVE DATA AND GENERAL CONSIDERATIONS.

The forms of the axial gradients in oligochaetes have already been observed by various authors on the basis of various lines of evidence[1]. But as far as I am aware, there are no data except those of SHEARER (1924) and PERKINS (1929) which concern the question of the axial differentials of oxidizable substances not only in oligochaetes, but also in the whole group of annelid worms. The present paper gives data concerning this question which were obtained by a method not previously used for this purpose and so adds to the evidence for the existence of axial gradients.

From the preceding results, it is clearly shown that the axial gradient of oxidizable substance in *Pheretima hilgendorfi* and *Allolobophora foetida* observed by means of the Manoilov reaction belongs to the *V*-shaped

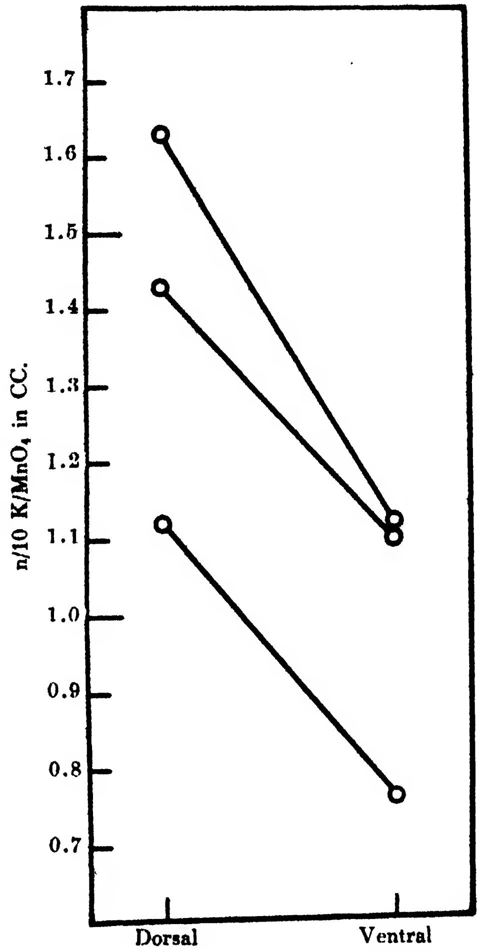

Fig. 3. Graphs showing the dorso-ventral gradients of oxidizable substance as determined by the Manoilov reaction in *Allolobophora foetida*. Upper curve from data with fuchsin as indicator, middle curve from data with dahlia and lower curve from data with light green.

[1] On Susceptibility to Cyanides by L. H. HYMAN (1916); On Respiration by L. H. HYMAN and A. E. GALIGHER (1921), T. OKADA (1929), M. PERKINS (1929); On Electrical Potential Distribution by T. H. MORGAN and A. C. DIMON (1904), L. H. HYMAN and A. W. BELLAMY (1922), Y. WATANABE (1928, 1930); On Galvanotaxis by A. R. MOORE (1923), A. R. MOORE and F. M. KELLOGG (1916); On Heat-Shortening Temperature and Content of Solid by S. HATAI (1924 a), Y. WATANABE (1930); On Distribution of Setae by S. HATAI (1924 b), G. E. PICKFORD (1930), P. B. SIVIKIS (1930); On Pigmentation, and Multiplication and Reduction of Nephridia by G. E. PICKFORD (1930); etc.

type (or secondary type) of oligochaete gradient like other gradients in higher oligochaetes in general.

In *Pheretima hilgendorfi* the amount of potassium permanganate needed for the oxidation is most at the preclitellar part and gradually decreases to a minimum near the posterior end, but again it rises a little toward the extreme end, and reaches a second maximum. Such a *V*-shaped gradient as this with a little posterior rise is found in several species of this genus *Pheretima*. HATAI (1924 a) has established the gradient forms of solid content and initial heat-shortening temperature in *P. divergens* (MICHAELSEN) and *P. megascolidioides* (GOTO et HATAI), and the writer (WATANABE, 1928, 1930) has also found the gradients of solid content, heat-shortening temperature and electrical potential in *P. communissima* (GOTO et HATAI). All these gradient forms are in general similar. The following Table IX and Figure 4 show the intimate resemblance in their gradient forms.

From these observations it appears probable that the *V*-shaped gradient with slight rise at the posterior end may be a characteristic form of physiological gradient in the genus *Pheretima*, although the distribution of setae in *P. megascolidioides* (HATAI, 1924 b) and in *P. benguetensis* BEDDARD (SIVIKIS, 1930) show much deeper *V*-shaped variations along the antero-posterior axis of the body.

In *Allolobophora foetida* the body was divided into only four pieces, but, even from these data, the gradient form of oxidizable substances in this earthworm can be satisfactorily established. The greatest amount of permanganate is required for the preclitellar piece, the next greatest for the posterior piece, and the amounts of permanganate required for the two middle divisions are a little less than for the other two. Such a *V*-shaped gradient as this with slight depth is apparently a characteristic form of gradient in this species. Table X and Figure 5 show the intimate correlation between the gradient of oxidizable substance, the heat-shortening gradient and the respiratory gradient in *Allolobophora foetida*. The heat-shortening gradient in *Allolobophora caliginosa* (SAVIGNY) is a little different in its form from that in *A. foetida*, indicating much greater posterior rise and needing higher temperature in the posterior region of the body than the anterior region (cf. data given in the last column of the Table X).

TABLE IX.

Comparative Data on Heat-Shortening Temperature, Content of Solids, Electric Potential and Oxidizable Substance, as Determined by the Manoilov Reaction, for Various Species of *Pheretima*.

Species			*P. divergens*		*P. megascolidioides*		*P. communissima*			*P. hilgendorfi*
Experiment			(1) Heat-Short.	(2) Cont. of Solid	(3) Heat-Short.	(4) Cont. of Solid	(5) Heat-Short.	(6) Cont. of Solid	(7) Electr. Potent.	(8) Manoilov Reaction
Unit			degree C.	%	degree C.	%	degree C.	%	m. v.	cc.
Ant.	*A*	I	40.1	21.1	41.2	21.1	40.2	21.2	−9.6	1.00
	B	II		20.6	41.2	20.9	39.7	20.3	−6.5	
Clit.	*C*	III		23.9	40.5	25.2	38.9	23.4	−4.8	0.87
Mid.	*D*	IV	37.2	19.0	39.7	19.6	39.2	19.5	−2.0	0.70
		V		18.4	39.4	18.3				
	E	VI		17.7	39.1	18.4	38.6	18.8	+0.9	0.65
		VII		17.8	39.0	17.7				
	F	VIII		17.6	38.9	17.7	38.0	18.3	+0.6	0.60
		IX		18.2	38.9	18.1				
Post.	*G*	X	38.5	18.0	38.9	18.3	38.4	17.3	+0.5	0.60
	H	XI		19.0	39.4	19.0	38.4	18.0	0.0	0.71

(1) Data given by HATAI (1924 a), p. 6. average of *P. divergens*, No. 1 and No. 2. (2) Ibid. p. 15, Table 2. (Average). (3) Ibid. p. 8. data of *P. megascolidioides* No. 4. (4) Ibid. p. 15, Table 2. (Average). (5) Data given by the writer (1930), p. 179, Table 16 c. (6) Ibid. p. 206, Table 24 c. (7) Ibid. p. 207, Table 25. (8) Data from foregoing Table II.

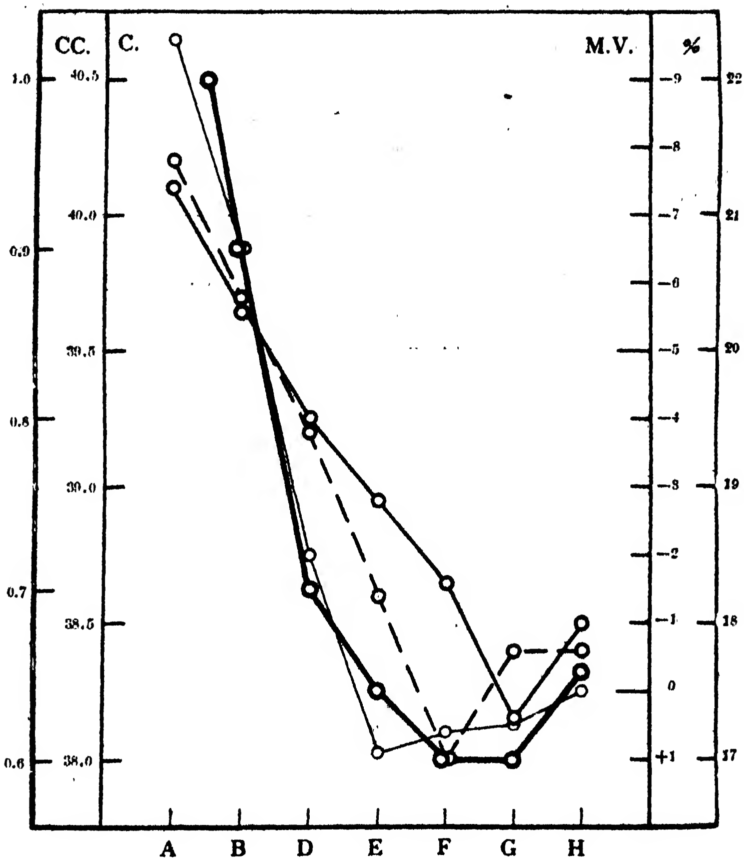

Fig. 4. Graphs showing the various gradients of the genus *Pheretima*. Heavy unbroken line indicates the gradient of oxidizable substance as determined by the Manoilov reaction in *P. hilgendorfi*. Medium unbroken line shows the gradient of solid content, broken line, the gradient of heat-shortening temperature and light unbroken line, the gradient of electrical potential, in *P. communissima*. These graphs are based on the data presented in Table IX.

TABLE X.

Comparative Data on Heat-Shortening Temperature, Oxidizable Substance as Determined by the Manoilov Reaction, and Rate of CO_2 Production for Two Species of *Allolobophora*.

Species		*A. foetida*			*A. caliginosa*
Experiment		(1) Heat Shortening	(2) Manoilov Reaction	(3) CO_2 Production	(4) Heat Shortening
Unit		degree C.	cc.	mgm	degree C.
A	*A*	40.2	1.36	0.0073	41.5
	B	39.8			41.2
M_1	*C*	39.7	1.14	0.0056	40.9
	D	39.45			40.8
M_2	*E*	39.45	1.07	0.0057	41.1
P	*F*	39.65	1.22	0.0073	41.5
	G	39.8			41.9

(1) Data from the writer's previous work (1930), p. 181, Table 17 c. (2) Data given in foregoing Table IV (with dahlia as indicator). (3) Data from Table XII, average values in fourth column, p. 461 in this paper. (4) Data from writer's previous word (1930), p. 182, Table 18 c.

From the data given in Table III to Table VIII, it is readily seen that the amounts of permanganate required for the tissue extracts of corresponding parts of the body are different according to kind of dye used in the reaction. Different amounts of permanganate are required with different dyes, because the data obtained from the Manoilov reaction indicate the total amount of the substances which are more readily oxidizable than the dye used. Therefore, if a larger amount of permanganate is required for decoloration of tissue extract with one dye as indicator than with another, the difference in amounts corresponds to oxidations which occur less readily than those represented by the smaller amount.

In order to determine these differences exactly we should employ the different dyes with the same sample of the extract, but in the case of *Allelobophora foetida*, unfortunately, it was not possible to prepare a sufficiently large amount of the exract for this purpose in

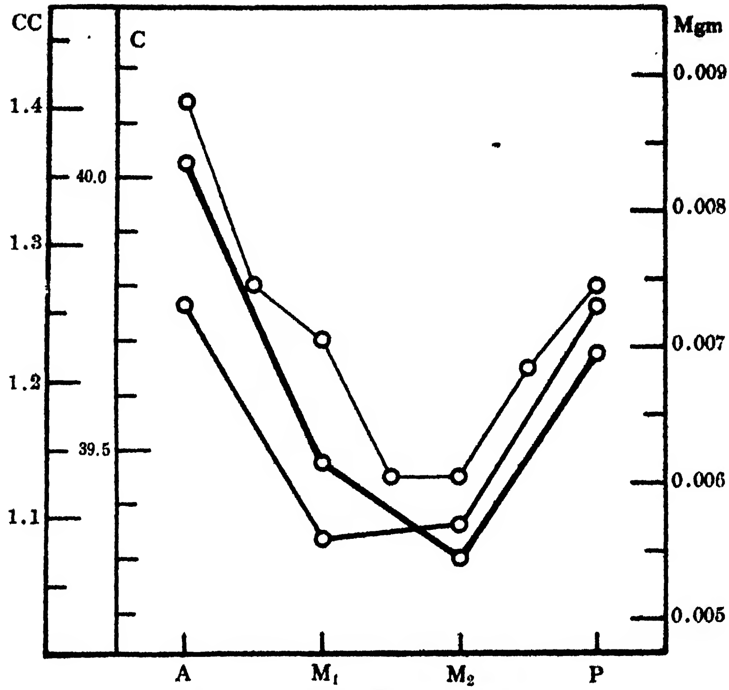

Fig. 5. Graphs showing the various gradients of *Allolobophora foetida*. Heavy line indicates the gradient of oxidizable substance as determined by the Manoilov reaction, medium line, the gradient of CO_2 production rate and light line, the gradient of heat-shortening temperature. These graphs are based on the data in Table X.

each test, since this species is not large enough to permit the preparation of sufficient amounts of tissues within the short time desirable in order to avoid possible unfavorable change of physiological condition before extraction. It was therefore necessary to employ the different dyes with different tissue samples. But even with this procedure, the differences in the different parts of the body are evident. The graphs in Figure 6 show these differences in different parts along the antero-posterior axis of the body in *Allolobophora foetida*.

When the amounts of permanganate required with the three different dyes are compared, it is found that in general the net amounts of permanganate required for each part of the body are least with light green, greater with dahlia and greatest with fuchsin, but the increments in the amount of permanganate in each case were differen

in different parts of the body, especially with fuchsin. The required amounts of permanganate for the middle parts were almost the same in the case of fuchsin as in the case of dahlia, while in the case of fuchsin the increment in amount of permanganate in the anterior (preclitellar) part was conspicuously large and that in the posterior part was also considerable as compared with the amounts observed with dahlia. Similar variations in amount of permanganate required were also found in the dorso-ventral axis of the body. The dorsal wall tissues always required a much larger amount of permanganate with all three dyes than the ventral wall tissues, and the increased amount of permanganate repuired for the dorsal wall in the case of fuchsin was also large as compared with that observed with dahlia,

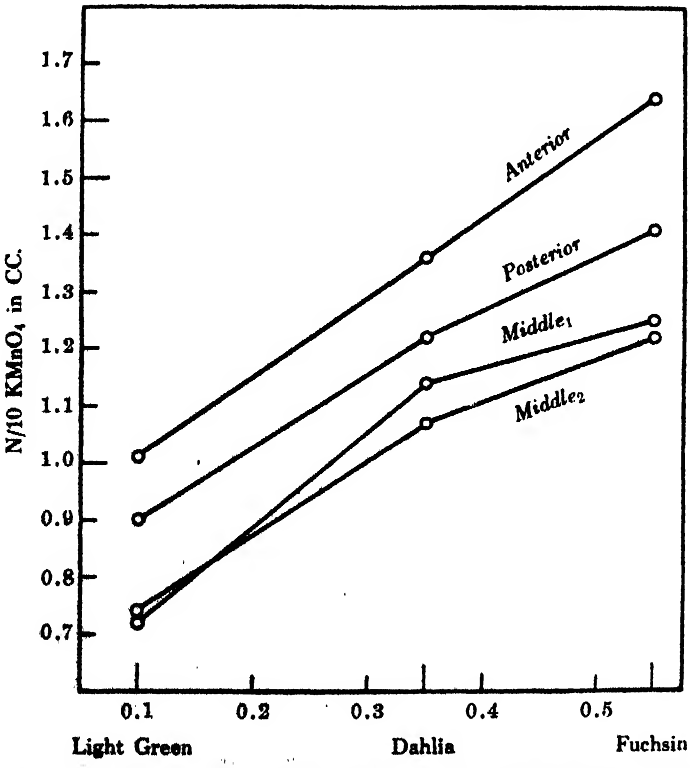

Fig. 6. Graphs showing the different amounts of permanganate required for different parts of the body in *Allolobophora foetida*, with three different dyes, light green, dahlia and fuchsin.

whereas, so far as I have observed, the amount of permanganate required for the ventral wall in the case of fuchsin was practically equal to that found with dahlia (cf. Figure 7).

These facts seem to indicate that the anterior and posterior parts of the body contain a much greater amount not only of easily oxidized substances, but also of substances not so easily oxidized, than the middle parts, and that the dorsal wall of the body contains substances less readily oxidized which are not found in the ventral wall tissues.

In the attempt to obtain further evidence on this point, I have tested 10 per cent extracts of several organs of the female rabbit. The results of this experiment are shown in Table XI and in Figure 8.

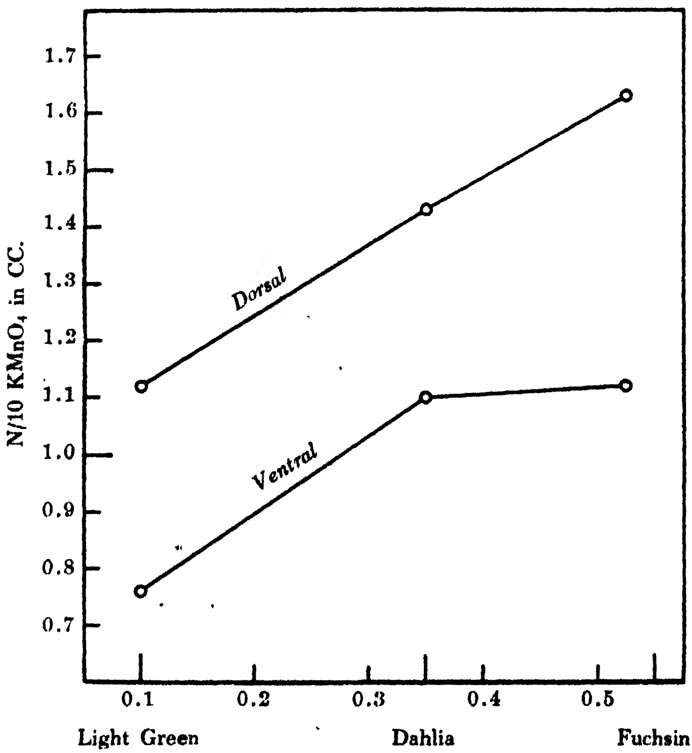

Fig. 7. Graphs showing the different amounts of permanganate required for the dorsal and ventral wall tissues of *Allolobophora foetida* with three different dyes, light green, dahlia and fuchsin as indicators. These graphs are based on the average values in Table VI to VIII.

TABLE XI.

Net Quantities (in CC.) of N/10 Potassium Permanganate Required for 3 CC. of 10 Per Cent Aqueous Extracts of Various Organs of Rabbit with Light Green, Dahlia and Fuchsin as Indicator.

Organ	Liver			Kidney			M. gastrocnemius			Heart			Stomach		
Dye	Light Green	Dahlia	Fuchsin	Light Green	Dahlia	Fuchsin	Light Green	Dahlia	Fuchsin	Light Green	Dahlia	Fuchsin	Light Green	Dahlia	Fuchsin
1	1.55	1.90	2.15	1.10	1.40	1.65	0.40	0.45	0.55	0.40	—	0.50	0.30	0.40	0.40
2	1.60	1.95	2.35	1.10	1.55	1.55	0.45	0.50	0.50	—	0.40	0.45	0.35	0.45	0.50
3	1.70	2.10	2.25	1.00	1.35	1.35	0.35	0.45	0.40	0.30	—	0.50	0.30	0.45	0.45
4	1.75	2.05	2.25	1.15	1.55	1.50	0.50	0.55	0.55	—	0.55	0.55	0.35	0.45	0.50
5	1.80	2.30	2.50	1.20	1.80	1.75	0.40	0.50	0.50	0.40	0.55	—	0.40	0.50	0.50
6	1.85	2.45	2.60	1.45	1.95	1.95	0.50	0.60	0.55	0.35	0.45	—	0.30	0.55	0.50
Average	**1.71**	**2.11**	**2.35**	**1.17**	**1.60**	**1.62**	**0.42**	**0.51**	**0.52**	**0.34**	**0.49**	**0.50**	**0.33**	**0.47**	**0.48**

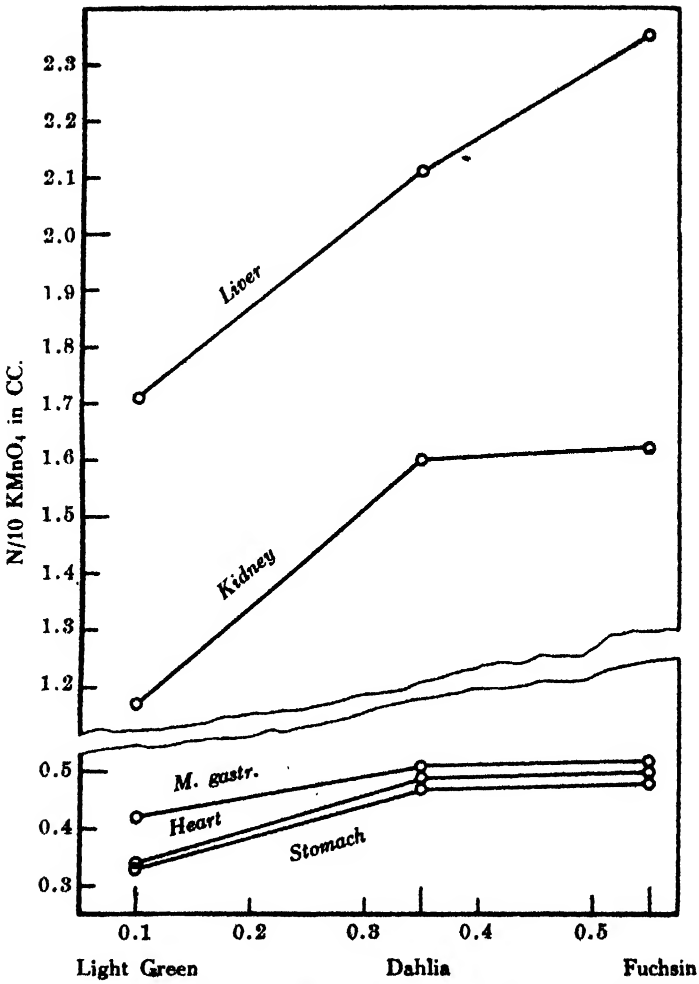

Fig. 8. Graphs showing the amounts of permanganate required for the extracts of various tissues of female rabbit with three different dyes, light green, dahlia and fuchsin as indicators. These graphs are based on the average values in Table XI.

As the data show, the liver extract required the largest amount of permanganate among all organs tested, the kidney extract the next largest amount, but *M. gastrocnemius*, heart and stomach required much less as compared with liver and kidney. And the amounts of permanganate for the extracts of muscle, heart and stomach were

practically equal with the three different dyes, while the kidney extract required a much greater amount of permanganate with dahlia than with light green, but almost the same amount of permanganate with fuchsin as with dahlia, and the liver extract required a much greater amount of permanganate with fuchsin than with dahlia and a much greater amount of permanganate with dalia than with light green. These facts probably indicate that the extracts of muscle, heart and stomach contain relatively easily oxidizable substances while that of the kidney contains also substances less readily oxidized or more capable of reducing the oxidizing agent, and finally the extract of liver contains substances still less readily oxidizable or still more capable of reducing the agent, which are not contained in the extracts of other organs.

It is scarcely necessary to point out that the Manoilov reaction is a test for the amount of water-extractable oxidizable substances, not for the intensity or the potential of the oxidation-reduction reaction, consequenly these data do not concern the question of the so-called oxidation-reduction potential in tissues. However, according to the classical work of EHRLICH (1885) with alizarin blue and indophenol blue, liver and renal cortex show a higher reduction potential than the muscular organs; this order corresponds, in general, to that obtained from the Manoilov reaction in the ring dove by RIDDLE and REINHART and in the rabbit by the writer. In connection with the data presented in the foregoing tables and the parallelism with EHRLICH's results, POLONOWSKI's statement, "Il importe aussi de noter que ce dosage manganimetrique n'a qu'un rapport des plus lointains avec la measure du rH des solutions examinées" (POLONOWSKI, 1929, p. 870), may be still worthy of note, although in the present state of our knowledge in this field it appears somewhat too positive.

For the purpose of comparing the gradient of oxidizable substance determined by means of the Manoilov reaction with the respiratory gradient in the earthworm, *Allolobophora foetida*, I attempted to determine the rate of CO_2 production of pieces from the different levels of the body. Certain data are given below, but more complete data and full discussion will be presented in another paper of this series of investigation on gradients. Here only the experimental conditions and certain data which concern the questions under discussion are recorded. For determination of the rate of CO_2 production,

PARKER's modification of the OSTERHOUT's indicator method (PARKER, 1925) was employed. The time required for change in hydrogen-ion concentration from pH 7.78 to 7.36 by the CO_2 production of the tissues was determined. The volume of the four respiratory chambers used here is 30.5 cc., 30.8 cc., 31.6 cc. and 32.2 cc. respectitively. The whole apparatus was continuously shaken 30 times per minute with a motor. The room temperature under which the experiments were carried on varied from 16°C. to 18°C. in the whole course of the experiments, but during each test the temperature change was, at most, only 0.8°C. The worms used as the material for this experiment were kept for a week and within this time the contents of the alimentary canal of the worm were completely evacuated. In order to avoid possible differences in effect of section on the respiratory rate the pieces from the two extremities were cut at the both ends like the middle pieces. The determination began immediately after cutting and was repeated every two hours after section. The weights of pieces were taken as the average value obtained from two weighings, after the first and fifth tests. The calculation of the CO_2 produced was made according to the formula of PARKER (1925). Three worms were used for each test.

In every case the rate of CO_2 production is highest immediately after cutting and decreases rapidly as time goes on, but after two hours, this decrease becomes very gradual, as shown in Figure 8. This high rate of CO_2 production from pieces immediately after sectioning is probably due to the effect of stimulation of cutting and as this effect decreases the rate of CO_2 production also decreases. In the first determination after cutting the middle pieces may show a rate almost as high as, or in some cases higher than that of anterior and posterior pieces, but as the effect of stimulation decreases the rates of anterior and posterior pieces become relatively higher as compared with the middle pieces, in other words, the rate of CO_2

TABLE XII.

CO_2 Production in Mgm. Per Gm. Per Minute of Pieces from Different Levels of the Body in *Allolobophora foetida*.

Time after Cutting	Immediately after Cutting	2 hours	4 hours	6 hours	8 hours
Experiment 1. Temp. 17.5–18.0 C.					
A	0.0154	0.0077	0.0074	0.0072	0.0074
M_1	0.0148	0.0060	0.0054	0.0055	0.0052
M_2	0.0186	0.0053	0.0049	0.0047	0.0052
P	0.0134	0.0067	0.0064	0.0065	0.0064
Experiment 2. Temp. 16.3–17.5 C.					
A	0.0135	0.0080	0.0088	0.0085	0.0078
M_1	0.0126	0.0062	0.0068	0.0065	0.0065
M_2	0.0156	0.0074	0.0072	0.0072	0.0069
P	0.0219	0.0080	0.0073	0.0075	0.0072
Experiment 3. Temp. 16.7–17.3 C.					
A	0.0130	0.0074	0.0074	0.0071	0.0069
M_1	0.0120	0.0056	0.0054	0.0056	0.0051
M_2	0.0185	0.0053	0.0052	0.0053	0.0049
P	0.0179	0.0074	0.0072	0.0068	0.0068
Experiment 4. Temp. 17.2–18.0 C.					
A	0.0121	0.0071	0.0068	0.0066	0.0066
M_1	0.0093	0.0068	0.0045	0.0045	0.0043
M_2	0.0148	0.0068	0.0065	0.0065	0.0063
P	0.0172	0.0095	0.0091	0.0088	0.0085
Experiment 5. Temp. 17.1–17.6 C.					
A	0.0106	0.0065	0.0060	0.0060	0.0053
M_1	0.0112	0.0063	0.0057	0.0053	0.0049
M_2	0.0224	0.0052	0.0046	0.0042	0.0042
P	0.0140	0.0069	0.0063	0.0060	0.0058
Average Values. (Temperature range, 16.3–18.0 C.)					
A	0.0129	0.0078	0.0073	0.0071	0.0068
M_1	0.0120	0.0058	0.0056	0.0055	0.0052
M_2	0.0180	0.0060	0.0057	0.0056	0.0055
P	0.0169	0.0077	0.0073	0.0063	0.0069

Designations of parts of the body are the same as used in Table III to V and are explained on p. 445.

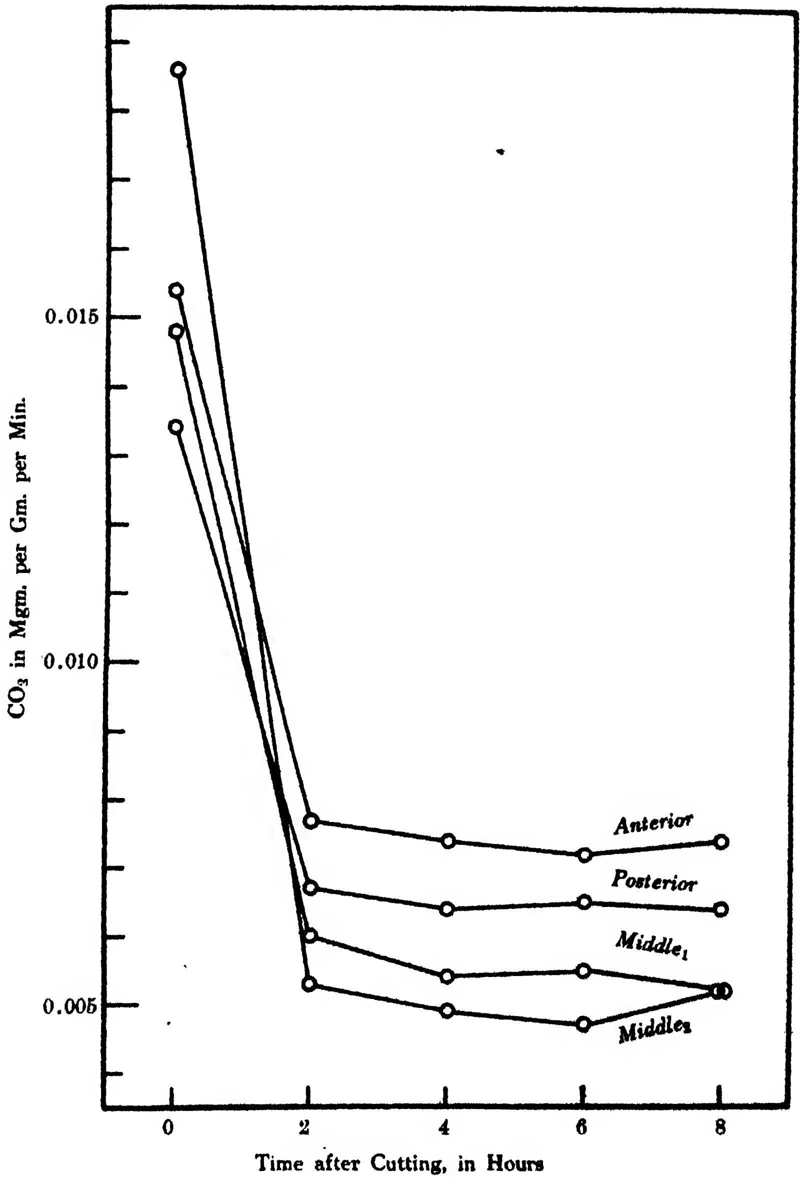

Fig. 9. Graphs showing the rate of CO_2 production of four different parts of the body in *Allolobophora foetida* which decreases as the effect of stimulation of sectioning decreases. These graphs are based on the data given in Experiment 1 of Table XII.

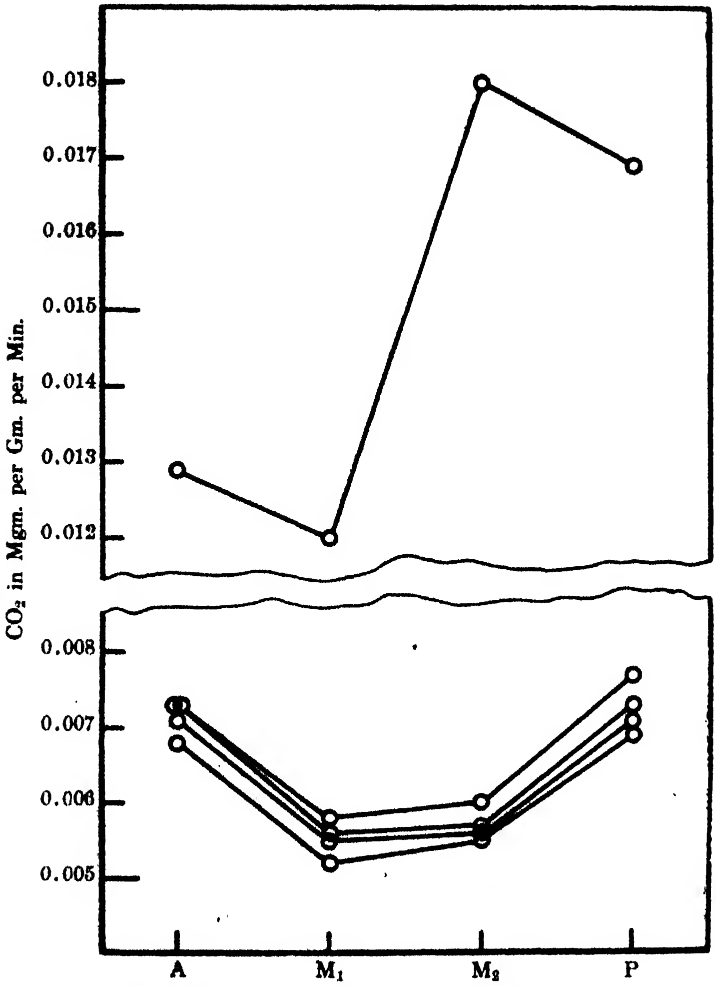

Fig. 10. Graphs showing the gradient of CO_2 production rate in *Allolobophora foetida.* Upper curve indicates the gradient observed immediately after cutting, and the group of lower curves show the *V*-shaped gradient observed at 2 hours to 8 hours after sectioning. These graphs are based on the averages in Table XII.

production of pieces from the different levels of the body comes to show a distinctly *V*-shaped gradient, anterior and posterior regions showing a higher rate than the middle. The change of gradient form is shown in Figure 10.

PERKINS (1927) found that the earthworms, *Lumbricus* sp. and *Allolobophora* sp.[1] showed the *V*-shaped gradient in oxygen uptake. HYMAN and GALIGHER (1921) found the double gradient in the oxygen consumption rate in *Lumbriculus varians* by the WINKLER's method, and OKADA (1929) has recently studied the respiration of the three different parts of the body in *Branchiura* sp. by means of VAN SLYKE's technique and found that *Branchiura* showed also distinctly a double (*V*-shaped) gradient with intense posterior rise in oxygen consumption as well as CO_2 production. Recently SHEARER (1930) has presented certain objections to the gradient theory based on his determination of oxygen uptake in planarian pieces. At present criticism of his objections is undertaken only on the basis of the data given above. The question may be raised why he did not re-examine the earthworm before presenting his objection, since his earlier paper (SHEARER, 1924) was in part concerned with the earthworm. SHEARER (1930) states that "In my chick and earthworm experiments, only a few determinations were made with these powders. The fact that those prepared from the head of the animals took up more oxygen than those of the tail portions was probably a mere coincidence. In one experiment the value was the same for both. In further experiments using these powders I could find little difference between head and tail portions of the animals." (p. 260). According to this statement, it appears that he did not recognize the existence of the double gradients in oligochaetes at all. Apparently he discards all his former data concerning the chick embryo and earthworm because he has not taken into consideration the effect of section on the respiratory rate in Planaria. It seems somewhat premature that, for the reasons which he presents, he should venture to deny the existence of any metabolic gradients in oligochaetes.

But returning the data of the present paper, it is evident that in *Allolobophora foetida* the gradient of oxidizable substance as determined by the Manoilov reaction corresponds fairly well with that of the CO_2 production rate. TERROINE and ROCHE (1925) investigated the oxygen uptake of various minced tissues, liver, kidney and muscle,

[1] PERKINS' paper in Nature the material was unnamed, but I have ascertained by personal correspondence that the earthworms which served as material for his experiment were *Lumbricus* sp. and *Allolobophora* sp.

in the pigion, rabbit and other warm-blooded animals, and found that the rate of oxygen uptake is highest in liver, next in kidney and least in muscle. This order corresponds well with that from the Manoilov reaction in ring dove (RIDDLE and REINHART, 1928) and in rabbit (cf. foregoing Tables I and XI). As RIDDLE and REINHART stated, the conditions of the two earlier series of experiments may be of course quite different, but the parallelism in result is at least notable. In my earthworm experiment, almost the same correlation can be observed between the data from the Manoilov reaction and the rate of CO_2 production. According to the conclusion given by TERROINE and ROCHE, the respiratory rate in vitro in tissues is directly proportional to the product of the content of protein material and phospholipoid. If this is the case, it is suggestive as regards the relation between the gradient of oxidizable substance and the respiratory gradient that the data from the Manoilov reaction, in which protein substances strongly protect the dye from decoloration by permanganate (GALWIALO and his associates, 1926, SCHMIDT and PEREWOSSKAJA, 1926), show a distinct correlation with the rate of respiration in tissues, even though we need far more direct evidence to say that this apparent correlation indicates a true causal physiological connection.

Since HOPKINS' work (1921) on glutathione as an autoxidizable constituent in cells appeared, the question of the relation of this substance to tissue respiration and to oxidation-reduction phenomena in living cells has attracted the attention of many workers. As regards the axial gradient of glutathione content, CHILD and HYMAN (1926) investigated it in the hydrozoan, *Corymorpha palma*. According to them, in this organism the gradient of this substance, as indicated by the nitroprusside reaction, corresponded closely with the respiratory gradient and other gradients observed by different methods, showing the deepest color in the hydranth region with gradual decrease in color intensity basipetally. But in the earthworms, *Allolobophora* and *Lumbricus*, PERKINS (1929) showed that the extractable reduced sulphydryl is present in largest quantity in the posterior half of the preclitellar part and gradually decreases posteriorly, while toward the head end it decreases steeply; and other reducing substances titrable with iodine show almost the same gradient shape as that of glutathione. These gradients clearly do not correspond with that of oxygen con-

sumption rate as shown by PERKINS himself. And the gradient of water-extractable oxidizable substance and of CO_2 production rate in *Allolobophora foetida* also do not correspond with them. Apparently, then, the gradient of glutathione does not correspond with the respiratory gradient in the earthworm, while in the hydrozoan it does. The reason for this difference is not evident, but it is possible as PERKINS has suggested[1], that at least earthworms, there must be other more important oxidation systems than the sulphydryl system, which play a part in determining the total metabolic rate of tissues.

Concerning this point, it is of interest to compare the amount of oxidizable substances as determined by the Manoilov reaction with the content of reduced glutathione in various tissues of the rabbit. The data cited below concerning glutathione are from the recent work of MATSUMORI and OKUDA (1930), who used PERLZEIG and DELRUE's modification of TUNICLIFF's method for the determination of glutathione content.

TABLE XIII.

Comparative Data on Content of Glutathione and Amount of Oxidizable Substance as Determined by the Manoilov Reaction in Rabbit Tissues.

Exper.	Content of Glutathione	M/10 $KMnO_4$ in CC. in Manoilov Reaction		
Dye		Light Green	Dahlia	Fuchsin
Unit	Per Cent	cc.	cc.	cc.
Liver	0.262	1.71	2.11	2.35
Kidney	0.152	1.17	1.60	1.62
M. gastrocnemius	0.047	0.42	0.51	0.52
Heart	0.084	0.34	0.49	0.51
Stomach	0.116	0.33	0.47	0.48

Data given in the second column are adopted from MATSUMORI and OKUDA's paper (1930), p. 413, Table II. and those of the Manoilov reaction, from the average values in foregoing Table XI.

[1] PERKINS has insisted that the gradient of growth in the earthworms corresponds with that of glutathione content, but I can not clearly understand what he means by the term "*growth gradient*".

As Table XIII shows, the content of glutathione in various tissues of the rabbit does not always correspond with that of oxidizable substances as determined by the Manoilov reaction. In the light of these data it appears less strange that the gradient of glutathione content in the earthworms does not accord with those of respiration and of oxidizable substance. Moreover, the real rôle of this substance in the cell metabolism may be said not to be sufficiently cleared up, though it must be of physiological importance. There seems to be almost no positive evidence for the existence of an intimate correlation between the content of glutathione of any tissue and its rate of respiration (MITCHELL and HAMILTON, 1929). And recently it has even been suggested that glutathione acts as one of the activators for the proteolytic enzymes both in plant and animal organisms (WAHRSCHMIDT-LEITZ, PURR and BALL, 1930; GRASSMAN, SCHAENEBECK and EIBELER, 1931; etc.), rather than as hydrogen-acceptor in cell oxidation. Until the part played by the glutathione in the total metabolism of the tissues is completely cleared up, it still remains to be determined why the glutathione gradient corresponds or does not correspond with that of respiration and that of oxidizable substance, and what significance the glutathione gradient possesses in relation to the metabolic gradients in organisms.

PICKFORD (1930) first suggested that the distribution of pigment along the axis of the body in the earthworms might be correlated with the metabolic gradient in general. PICKFORD observed the pigmentation of *Lumbricus terrestris* Lin. and stated that it is " intensely pigmented dorsally at the anterior end, the pigmentation extending laterally to about *cd* (the line of the lateral setae), the first three segments also slightly pigmented ventrally; posterior to the clitellum the lateral extent of the dorsal pigmentation becomes reduced until only a mid-dorsal line is left which persists through the posterior half of the body; at the extreme posterior end there is again an increase in intensity and extent of pigmentation (except on the terminal segment which is small and pale) which extends laterally to below the setal line *cd* on the seventh to the second last segments and even faintly on the ventral side of the second, third, and fourth segments from the end." (PICKFORD, 1930, p. 276). That is to say, according to this observation, the distribution of pigment in *Lumbricus terestris*

may be said to show the double type of gradient.

According to the work of SASAKI (1924) on '*Allolobophora foetida* (SAV.) in North Japan', "This worm, when it is alive, has a very characteristic coloration; each dorsal segment shows three stripes, light red in front, deep red mixed with purple in the middle, followed again by light red, with exception of segments IX, X and XI and of the clitellar portion, in which the coloration is somewhat weaker. The ventral is nearly the same as the dorsal, only somewhat whiter." (SASAKI, 1924, p. 89). As regards the dark red stripe in the middle of each segment, except in segments IX, X, and XI and clitellar segments, pigmentation is most intense in several segments at the anterior end, and gradually decreases posteriorly, but without any increase at the posterior end segments and it shows almost the same intensity of color and lateral extent of dark tint and also almost the same width of stripe in relation to the segment width through the postclitellar part of the body. The width of the dark red stripe is relatively greater in several anterior segments and its lateral extent also greater in those segments; the dark red stripe extends around the whole segment in the first seven segments, in eighth segment a mid-ventral part is not covered by the dark tint and the lateral extension of the stripe decreases to a region near the setal, line *cd* in the fifteenth segment and all following segments. As regards the two paler stripes no considerable gradation in color along the axis of body has been observed. Therefore, if we can assume that the pigmentation gradient in this earthworm may be represented by that indicated by the middle dark red stripe in each segment, it shows the single gradient, which does not correspond with the gradient of respiration and that of oxidizable substance. In *Allolobophora foetida*, at any rate, I can not find such a marked reduction of the pigmentation in the segments of the middle region of the body as PICKFORD observed in *Lumbricus terrestris*. However, in this earthworm also the dorsal body wall is, of course, more intensely pigmented than the ventral, so that this dorso-ventral gradient in pigmentation corresponds to that of oxidizable substance. The observation and suggestion given by PICKFORD are of interest in relation to the gradient hypothesis, but, so far as I have attempted to compare various gradients with each other in *Allolobophora foetida*, it is evident that more knowledge

concerning the physiological relation between morphological pigmentation and metabolic activity is necessary before it can be positively stated that the gradient of pigmentation is one of the morphological concomitants of the metabolic gradient.

SUMMARY.

1. The Manoilov reaction was used as a quantitative test for oxidizable substance and applied to investigation of the axial gradients of earthworms, *Pheretima hilgendorfi* and *Allolobophora foetida*.

2. The amount of oxidizable substances as determined by the Manoilov reaction is different in different parts of the body of worm, and varies longitudinally in the form of a double (*V*-shaped) gradient like other gradients of higher oligochaetes in general.

3. In *Pheretima hilgendorfi* the gradient of oxidizable substance as determined by the Manoilov reaction shows a *V*-shaped type with a slight posterior rise, which apparently is a characteristic form of gradient of the genus *Pheretima*. In *Allolobophora foetida* the gradient of oxidizable substance also belongs to the *V*-shaped type of gradient, but the depth in the middle region of the body is slight. This shallow double gradient seems to be a characteristic form of the gradient of this species.

4. The tissues of the dorsal wall contain greater amount of oxidizable substances as determined by the Manoilov reaction than those of the ventral wall.

5. In *Allolobophora foetida* experiments with three different dyes which differ as regards permanganate equivalent for oxidation and decoloration, viz. light green, dahlia and fuchsin, as indicators, it is found that the anterior and posterior parts of the body contain a much greater amount than the middle parts not only of easily oxidized substances, but also of substances less easily oxidized, and that the dorsal wall of the body contains substances less readily oxidized which are not found in the ventral wall tissues.

6. For purposes of comparison data concerning CO_2 production in *Allolobophora foetida* have been obtained by means of PARKER's method. The rate of CO_2 production for each part is highest immediately after cutting and decreases rapidly as time goes on, but after

two hours this decrease becomes very gradual. In the first determination after cutting the middle part may show a rate almost as high as, or in some cases higher than that of anterior and posterior parts, but as the effect of stimulation decreases the rate of anterior and posterior parts becomes relatively higher as compared with the middle parts, that is to say, the rate of CO_2 production of different parts of the body comes to show a distinct *V*-shaped gradient.

7. Some comparative data on the Manoilov reaction in various tissues of rabbit are presented in the text.

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On the Induction of the Medullary Plate in *Hynobius*.

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(With 31 Text-figs)

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INTRODUCTION

In 1924 it was shown by H. Spemann and H. Mangold that when a piece of the dorsal lip of the gastrula of an Amphibian embryo is transplanted into the relatively indifferent part of the other embryo, the piece rolls in from the surface and produces an organizing effect to induce a secondary medullary plate in the neighbouring part of the presumptive epidermis of the host embryo. This function was called " Organisator " by Spemann and the dorsal lip of the gastrula was assumed to be the center of the organization. In 1925, Geinitz found a new modification of the method of the transplantation. According to him, the organizer was inserted into the blastocoel of a blastula or a gastrula. With this method the organizing effect is tested in a wider range, even in the animal pole of the embryo. And, moreover, complete fusion between the implant and the host tissue is not necessary. He succeeded in showing induction between species (heteroplastic) and genera (xenoplastic). Up to the present time homoeoplastic and heteroplastic induction has been show in *Triton taeniatus*, *T. alpestris* and *T. cristatus* by Spemann and H. Mangold ('24), Marx ('25) and H. Mangold ('29). And when *Triton taeniatus* was used as a host, the xenoplastic induction of the organizers of *Pleurodeles waltli*, *Amblystoma mexicanum*, *Rana esculenta*, *Rana temporaria* and *Bombinator pachypus* were shown by Geinitz ('25). Recently Schotté ('30) attempted to experiment with the induction on the Anuran host. But the detailed results of his experiment are not yet published.

In the early period of the discovery the topographic range of the

organizer was assumed only in the limited region of the embryo. According to BAUTZMANN ('26) it coincides approximately with the presumptive area of the chorda and mesoderm of the early gastrula stage of VOGT's observation. In the next year SPEMANN and GEINITZ ('27) showed that a piece of presumptive epidermis acquires organizing power if it is transplanted in a portion of the dorsal lip and left there same while. This is called "sekundärer Organisator" by the authors. The authors showed the induction of the medullary plate in the overlying epidermis by implantation of the secondary organizer in the blastocoel of the other embryo. After this the organizing function was detected in many other parts and various stages of the embryo. That is, in the medullary plate of the neurula stage by two authors, O. MANGOLD and Spemann ('27) independently; in the chorda of the neurula stage by BAUTZMANN ('28, '29); and in the brain of the embryo by O. MANGOLD ('29).

The problem of the stage of the first appearance of the organization center remains untouched. But many observations on the gray crescent of the Anuran egg and the experiments of the homoeoplastic and heteroplastic fusion of two complete embryos at the two cell stage in *Triton* suggest us that the center of organization may already be present before the first cleavage stage.

On the structure of the organizer, BAUTZMANN ('29) and SPEMANN ('29, '31) studied independently and they came to the same conclusion. BAUTZMANN used the chorda of the neurula as the organizer. He divided the chorda into two parts, anterior and posterior, and observed their induction effect in the anterior and posterior part of the host. SPEMANN also used two sorts of organizers; one is the "Kopforganisator", which is taken from the anterior portion of the roof of the archenteron or from the lower portion of the dorsal lip of a young gastrula, and the other is "Rumpforganisator" which is taken from the posterior portion of the roof of the archenteron or from the upper portion of the dorsal lip of a young gastrula. Therefore the principles of the experiment of both authors are the same. The results of the experiments of both authers are summarized as follows. The induction by the posterior half of the chorda or "Rumpforganisator" in the posterior portion of the host is adapted for the host; and the posterior part of the medullary plate is induced. The induc-

tion by the posterior half of the chorda or "Rumpforganisator" and by the anterior half of the chorda or "Kopforganisator" in the anterior part of the host are also adapted for the host. And in these cases the structures of the anterior parts of the medullary plate are induced notwithstanding the presumptive position of the organizers. But in the case when the anterior half of the chorda or a "Kopf-organosator" is applied to the posterior part of the host, the induced structure is related to the organizers. Therefore, the structures of the anterior part of the medullary plate are formed even in the posterior part of the host. From these experiments it is probable to assume a sort of structure in the organizer, and in the same way a structure or differentiation must be assumed also in the host. SPEMANN admitted a role of the axial gradient of CHILD's idea in the phenomena of the organization in some points.

On the nature of the induction phenomena our knowledge is very poor. According to SPEMANN this is assumed to be of a chemical nature. Recently MARX ('30) showed that a piece of the dorsal lip, which has previously been narcotized with a strong concentration of an anaesthetic such as 0.6% trichlorbutylalcohol for one hour and fifteen minutes or two hours and forty minutes shows the induction of the medullary plate, when it is implanted into the blastocoel of the other normal gastrula. This experiment suggests that the power of the induction is independent of the cellular activity of the organizer. MARX had assumed the presence of free material or energy in the organizer.

Since last year I have also studied the SPEMANN effect* in the Japanese species of Amphibia. In the following pages I shall describe the results of my study, which is observed in *Hynobius unnangso* TAGO.

Here I wish to express my hearty thanks to Dr. K. TAGO for his kind identification of the species used in my experiment.

* Among the entwicklungsmechanists different meanings are expressed by the word "induction". To avoid troublesome confusion of ideas, and to commemorate SPEMANN's discovery I propose to name the phenomena of induction of the medullary plate by the organizer in Amphibian embryo "SPEMANN effect".

MATERIAL AND METHOD

In this experiment the egg of *Hynobius unnangso* TAGO was used. This species is very common in the northern part of Japan. The breeding season begins towards the middle of March and ceases in the middle of April in Sendai. The eggs are laid in a cold stream. The egg sac is always paired and is attached on the surface of a stone or a root of a tree. In an egg sac twenty to forty grains of the egg are enclosed with a concentrated mass of the transparent jelly. Each of the eggs is covered with a membranous ellastic capsule. In the early stages, the egg is covered closely with a very thin vitelline membrane. The egg is very large. It is about 2.6 mm. in diameter. The animal pole is greenish brown or dark brown and the vegetal pole is greenish light yellow.

The material was collected from a stream in the neighbourhood of the laboratory. I did not attempt artificial fertilization in this species.

For the instrument of operation, glass needles, looped hairs and watchmakers' pincettes were used. Operation and culture of the embryo were carried out in a small PETRI dish 1.5 cm. in depth and 4.5 cm. in diameter. Following SCHOTTÉ's idea ('30), I put a sheet of Japanese silk, Habutae, 5 cm. square on the bottom of the dish.

For the culture medium of the operated embryo MANGOLD's modification* of RINGER's solution for the embryo of *Triton alpestris* is most suitable for the embryo of *Hynobius unnangso*, as far as I tried. In the course of operation, I used the concentration of two times this solution.

WOERDEMAN ('30) maintained the necessity for the sterilization of culture medium and instruments for diminishing the mortality of the embryo. This is also good for a feeble embryo such as *Hynobius*. But it is an ununderstandable thing to me that the operated embryo did not remain alive more than five days, notwithstanding my care. The embryo was fixed in MICHAELIS' fluid and stained in bulk with alcoholic borax carmine. The thickness of the section was 15 to 20 micra.

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* NaCl 0,7 gr., KCl 0,025 gr., CaCl 0,3 gr. and H_2O 1000 c.c..

EXPERIMENT.

The organizer was taken from the dorsal lip of the young gastrula. A piece of the dorsal lip was inserted inside-out into the blastocoel of the young gastrula of the same stage. The transplantation of the organizer in the indifferent portion of the surface of the embryo was not tried. In seven sets of experiments 57 specimens were operated upon, and in 15 specimens the induction phenomenon was observed.

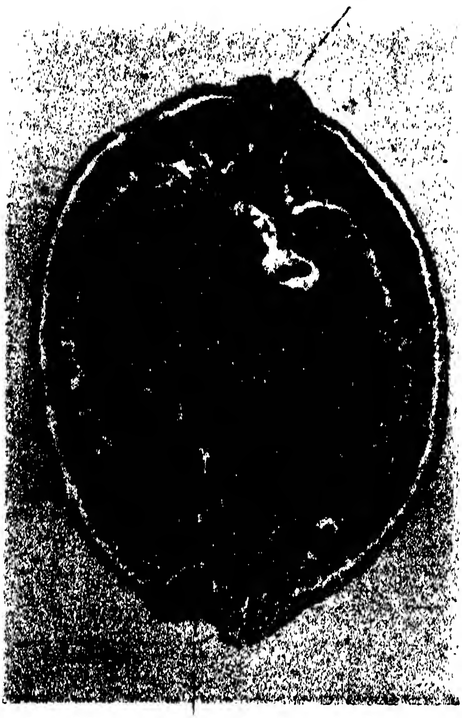
No. 207. The donor and host embryo were young gastrula from the same egg sac (Fig. 19). A piece of dorsal lip was cut out and inserted into the blastocoel of the host through the small slit made just before with a glass needle at the animal pole. Within a few hours the whole embryo became flat on account of the plasticity of the cytoplasm. In the next day the yolk plug flowed out from the blastopore. Three days later, most of the yolk plug was taken into the blastopore, but a small portion still remained. The primary medullary plate appeared in this day. After four days the embryo was fixed. The primary medullary plate had closed (Fig. 1). The secondary medullary plate was in the opposite side to the primary (Fig. 2). The anterior portion of the secondary medullary plate was

1 2 3

Figs. 1, 2 and 3. No. 207. Four days after operation.
Fig. 1.—dorsal view; Fig. 2.—ventral view. Fig. 3.—the same; the straight line shows the position of the section.

wide but the posterior portion was a narrow streak. In the middle of the anterior portion a white, conical process was observed. In cross sections, the thickening of the ectoderm was observed at the dark portion of the secondary medullary plate. The location of the

M1



M2

Fig. 4. No. 207. Cross section. M_1 — The neural tube of the primary anlage. M_2 — The secondary medullary plate.

implant was not obvious but just beneath the white conical process a large cell mass was observed, which was probably the implant. The black streak was also the thickening of the ectoderm (Fig. 4). A slight differentiation of the somite and probably of the chorda was observed in the secondary anlage.

No. 1411. The donor and the host were young gastrula from one egg sac (Figs. 17 and 18). The organizer was taken from the dorsal lip and inserted into the blastocoel of the host. In the next day a circular blastopore was observed. Two days later, a black streak appeared in the surface of the embryo. Three days later, the primary medullary plate and a head-like process at the side of the embryo were observed. Four days later, the embryo was fixed. The primary medullary plate had just closed (Fig. 5). The secondary

medullary plate began at the tip of the head-like process, reaching to the posterior end of the primary neural tube. Therefore the axes of the primary and the secondary anlages made an angle of about sixty degrees.

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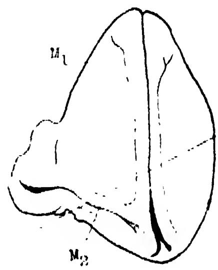

Figs. 5 and 6. No. 1411; four days after operation. M_1 — primary anlage; M_2 secondary anlage.

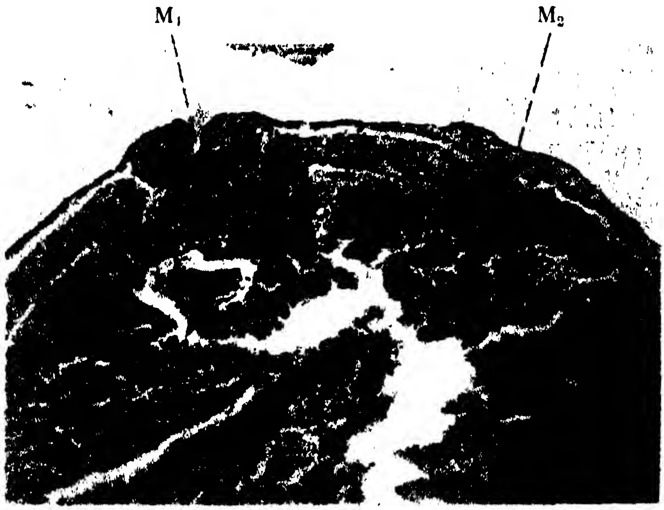

Fig. 7. Cross section of No. 1411. M_1 — Primary neural tube. M_2 — secondary medullary plate.

In sections, the posterior portion of the secondary medullary plate was poor, (Fig. 7) and in the anterior portion irregular thickenings of the ectoderm were observed. The implant was clearly distinguished from the tissue of the host because the nuclei showed pycnosis and

the cell boundary disappeared. From this point it is conceivable that the implant may already have died in the host tissue before the specimen was fixed. Mesoderm was observed beneath the secondary medullary plate but the differentiation of the chorda was not distinct.

No. 1412. The donor and the host were the same as before. A piece of the dorsal lip was inserted into the blastocoel of the host.

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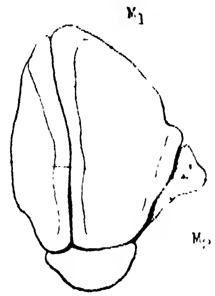

Figs. 8 and 9. No. 1412. four days after operation.

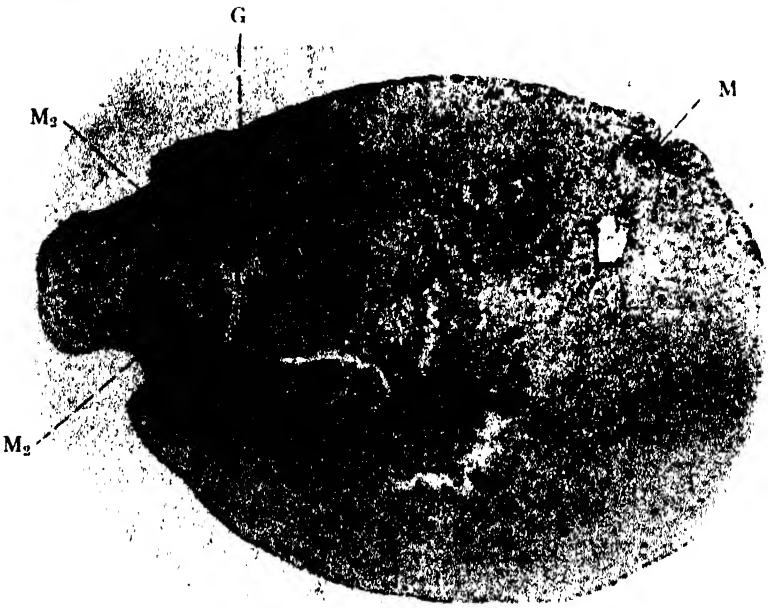

Fig. 10. Cross section of No. 1412. G — The intestinal cavity of the secondary anlage.

Four days later, the specimen was fixed. In this specimen the yolk plug was not involved completely and a little portion of it was remaining outside of the blastopore (Fig. 8). The primary medullary plate had just closed. The secondary medullary plate was to the right side of the primary. A conical process had formed in the secondary medullary plate.

In sections, very distinct thickenings of the ectoderm were observed on both sides of the conical process (Fig. 10). They proceeded posteriorly to the blastopore lip. The implant was found beneath the conical process. A secondary intestinal cavity was observed Differentiation of the chorda and somites was not observed in the secondary anlage.

No. 1416. The donor and the host were the same as before. The operation was carried out in the same manner as in the former specimens. Four days later, the specimen was fixed. The specimen had a small yolk plug outside of the blastopore. The induction was very irregular. A head-like process had been formed at the oposite side of the primary neural tube (Fig. 11). The epidermis of the head-like process showed many foldings and two distinct thickenings were formed at the base (Fig. 13). The implant was found in the head-like process and a part of the implant had decayed before the specimen was fixed. In the preparation, the decayed portion stained deeply with carmine (Fig. 13). The remaining portion of the implant had not differentiated the structure of the somites or chorda.

No. 206. The donor and the host were taken at the same stage from the same egg sac as in No. 207. The operation was carried out in the same manner. Two days after operation, the specimen was turned over so as to put the yolk plug upwards. Three days

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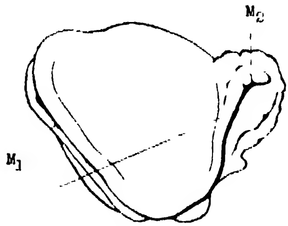
12



Figs. 11 and 12. No. 1416. four days after operation.

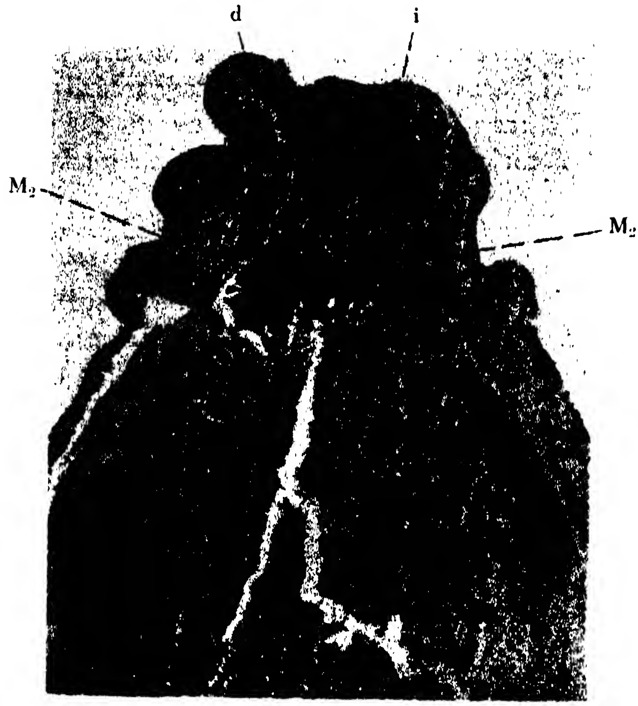


Fig. 13. Cross section of No. 1416. d — decayed portion of the implant. i — implant.

later, the primary plate was formed. Four days later, the specimen was fixed. The posterior portion of the primary medullary plate had closed but the anterior portion remained open. And at the anterior end of the embryo a thickening of the ectoderm had been induced

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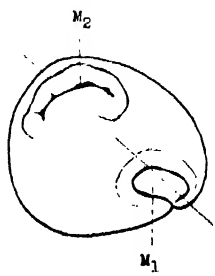


Figs. 14 and 15. No. 206. four days after operation.

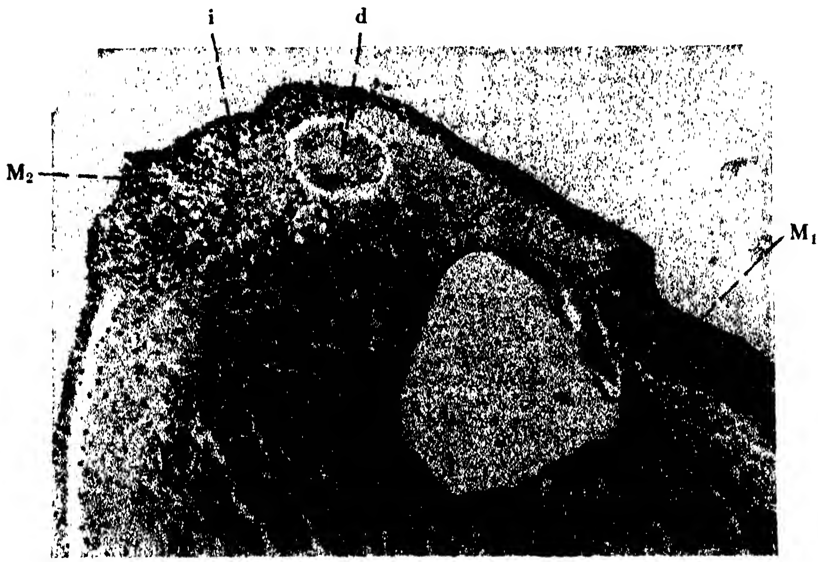


Fig. 16. Cross section of No. 206.

(Fig. 14). In sections a very thick primary medullary plate was observed but the induced ectoderm was irregular and thinner than the primary (Fig. 16). The implant was found in a very irregular shape beneath the induced ectoderm, and a small portion had decayed and was enclosed in the space between the ectoderm and entoderm of the host. Differentiation of the chorda and somites was not observed in the secondary anlage.

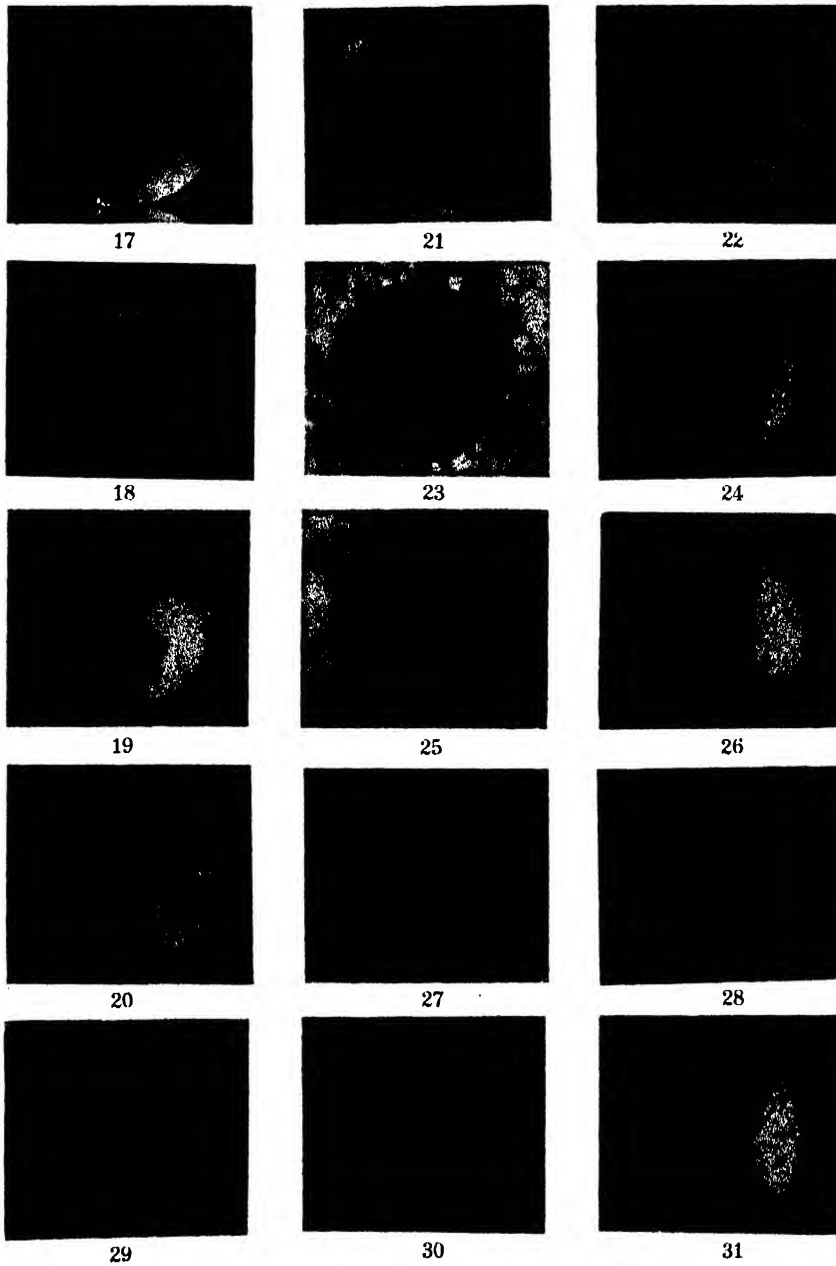
DISCUSSION.

The speed of development of the egg is relatively slow in *Hynobius unnangso.* The following table is a record observed by the author in 1929 at a room temperature of about 15 degrees. The time was calculated from the stage of the first appearance of the dorsal lip which is about three days after the first clevage.

The dorsal lip appears at about 66 degrees below the equator (Figs. 17 and 18).

12 hours later, a semicircular blastopore is observed. Its upper margin is about 11 degrees below the equator (Fig. 19).

24 hours later, the yolk plug is observed.



Figs. 17–31. Successive stages of gastrulation and neurulation in *Hynobius unnangso*. 17 — invagination of the dorsal lip; caudal view. 18 — the same photographed from vegetal pole. 19 — 12 hours after the begining of gastrulation; caudal view. 20 — 36 hours later; caudal view. 21 — 42 hours later; dorsal view. 22 — the same; caudal. 23 — 48 hours later; dorsal. 24 — the same; caudal. 25 — 54 hours later; dorsal. 26 — the same; caudal. 27 — 60 hours later; dorsal. 28 — the same; caudal. 29 — 62 hours later dorsal view. 30 — 70 hours later; dorsal view. 31 — the same; caudal view.

36 hours later, the diameter of the yolk plug is about one-fifth of the egg diameter, and the dorsal lip in about 27 degrees below the equator (Fig. 20).

42 hours later, the outline of the medullary plate appears. The yolk plug is very small (Figs. 21 and 22).

48 hours later, the lateral margin of the medullary plate is lifting (Figs. 23 and 24).

54 hours later, the margin of the medullary plate lifts up on all sides (Figs. 25 and 26).

60 hours later, the lateral margins of the medullary plate come up to the median line (Figs. 27 and 28).

70 hours later the medullary plate closes completely (Figs. 30 and 31).

And in the operated embryo, development is much more prolonged than in the normal embryo. This is mostly caused by the retardation of gastrulation. Just four days after the operation, the primary medullary plate of the operated embryo reaches the stage to which the normal embryo will arrive after three days or slightly more. Therefore the operated embryo is so young when it is fixed that the somites and chorda are only slightly differentiated in the primary anlage. And in many cases the differentiation of the somites and chorda is hardly visible in the secondary anlage. For observation of the relation between the induced embryonal anlage and the structures of the implant and also of the host, the operated embryo ought to be cultured at least six days or more. This was not possible for me because of the delicacy of the embryo. But it will be admitted from my experiment that the induction of the thickening of the ectoderm by the organizer was demonstrated in *Hynobius unnangso*.

Decayed tissue was found in Nos. 1411, 1416 and 206. This suggests that the cellular activity of the inplant was more or less disturbed through submitting the implant to abnormal conditions. But whether the cellular activity is independent of the inducing power of the organizer or not, it is impossible to answer from this experiment.

SUMMARY.

In *Hynobius unnangso.* TAGO, the induction effect of the organizer was observed. In this experiment a piece of the dorsal lip was

inserted, through an incision made in the upper hemisphere, into the blastocoel of an embryo in a same stage. The secondary medullary plate and the thickening of the ectoderm were induced in the ectoderm beneath which lays the inserted fragment of the dorsal lip.

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A Quantitative Investigation of the Plankton of Aomori Bay, as Studied Comparatively by Pump and Net Collection.[1)]

By

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(With 11 Text-figures)

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1) INTRODUCTION.

On setting about the present investigation care has been taken in respect to the following points: First, to clear up the quantitative relation of the plankton of Aomori Bay in which the hydrographical and consequently the biological conditions are far from being the same as those of the neighbouring open sea; Secondly, to study the vertical distribution of plankton in such shallow water as is throughly illuminated down to sea bottom; Thirdly, to test whether it may be possible to use our ordinary or Hensen-type net for quantitative purpose in the neritic area where the diatoms flourish abundantly.

Apart from physical conditions such as temperature, sunshine etc. the vegetation of phytoplankton is mainly due to the nutriment in the water. In Aomori Bay which receives an enoumous quantity of inland water the nutrient condition seems to be beneficial for their vegetation, and in addition the dilution of salinity of the water also might favour their propagation, thus causing the diatoms to flourish exceedingly. Therefore it was anticipated to be of interest to study the abundance of the plankton of this area with the hope of comparing it to that of other seas.

With regard to the vertical distribution of phytoplankton in the open sea it is generally accepted that they attain so deep as 200 meters and sometimes more than 400 meters in vivid condition. On the other hand it is also well known that in a fresh water lake of

1) Contribution from the Marine Biological Station, Asamushi Aomori-Ken. No. 67.

moderate depth phytoplankton shows sometimes remarkable vertical distribution. Therefore it was probable that they might show some remarkable relation in their vertical distribution in our bay, although the depth of it is mostly under 50 meters. The possibility of vertical migration of phytoplankton also attracted our attention for the reason that they might alter the quantity of fatty substance or other hydrostatic fluid in their body on account of the diurnal or seasonal change of the intensity of light, thus causing a change in their bouyancy and, accordingly, in their migration.

During the sojourn of Prof. C. KOFOID in our laboratory he constructed a small and slender plankton net which thereafter was used by us for qualitative purposes and which proved very suitable. As the filtration coefficient of this net was supposed not to be large, we had the desire of using it for quantitative vertical hauls. Therefore it was necessary for us to determine the filtration coefficient of this net by comparing its catch to that of the pump. Besides having this end in view we further hoped to determine the quantity of plankton accurately by the pump method. This was the reason for our attempting this comparative investigation.

2) HYDROGRAPHICAL CONDITIONS OF AOMORI BAY.

This bay is oblong, running north and south, and at the mouth through which the bay communicates with Tsugaru Channel the depth shows about 70 meters and the width about 11 km between the large headlands, named Tsugaru and Shimokita Peninsula. The southern one-third of the whole area is shallower and the remaining northern part is deeper than 36 meters (20 fathoms), the deepest part being about the mouth of the bay, measuring about 77 meters (43 fathoms). Though it is unlikely that the Tsugaru Current which passes the Tsugaru Strait enters the bay directly, waters of the strait and bay seem to be always mixing with each other by tidal current. On this account the chemical and physical factors of the waters of the strait and bay stand in a little different but constant ralation.

The salinity of the water of Aomori Bay is a little less than that of the neighbouring seas, showing its mean value to be 1.0234 in mean specific gravity. This value shows a seasonal change due to

the addition of a varying quantity of inland water at least so far as concerns the surface water. According to HATAI and KOKUBO (1928), in 1926 the specific gravity of the surface water decreased to 1.0217 in April on account of the increasing discharge of river water in this season due to snow water of the plains of the neighbouring district. The temperature of the surface water ranges between the monthly averages of 5.18°C (Feb.) and 22.83°C (Aug.), showing a minimum value of 3.20°C respectively.

Probably due to the low salinity of the sea water in the absence of a strong current, the biological conditions of the bay seem to be very different from those of the Tsugaru Strait. For instance, the Laminaria which is abundantly found in the strait does not exist in the bay, while the oyster which is a common inhabitant of the bay seems to be almost absent from the strait. As for the thermic character of the fauna of this bay Prof. KOFOID (1930) states it to be warmly temperate, basing his conclusion on the study of *Dinoflagellata fauna.*

The collections of the present investigation were made at a station about 1 mile off our laboratory. The duration of the observation was from Aug. 26, 1930 to Apr. 14, 1931 with 12 times of collection. The depth of the observing station was 31 meters, and was of muddy bottom.

The hydrographical and meteological factors observed during the experiment are shown tabulated as follows (next page):

3) THE METHOD AND APPARATUS.

The apparatus used consisted of a common wing pump and two kinds of plankton net. The catches of this apparatus were compared in order to determine the filteration coefficient of the net.

a) COLLECTION BY PUMP. In 'Vierwaldstattersee' BACHMANN (1900) collected the plankton from the surface to the 70 meter stratum by pumping 6 to 20 litres of water. He used 'Müllergaze' of No. 25 (No. 20 in these days) for the filteration of plankton. The suction tubing he used was 10 mm in diameter and for the suction of 10 litres of water from the surface and the 70 meter depth 5 and 15 minutes were needed respectively. LOHMANN (1903) likewise made

Table of observations.

No. of obs.	Date of observation	Air temp.	Water temperature							Forel's scale	Transparency (m.)	Vol. Pl. per c.m.	Weather
			0 m	5 m	10 m	15 m	20 m	25 m	30 m				
1	Aug. 26, 1930. 10.00–11.00 a.m.	26.2°	26.3°	25.8°	25.5°	—	25.2°	—	24.2°	No. 4	11	78.96cc	Cloudy day, glass calm. previous day breeze.
2	Sept. 11, 1930. 3.00– 4.00 p.m.	26.2°	23.7°	23.5°	23.8°	—	23.0°	—	22.8°	No. 4	11	257.52 ,,	Sunny day, glass calm. previous day west breeze.
3	Sept. 25, 1930. 2.00– 3.00 p.m.	23.6°	22.5°	—	—	—	—	—	—	No. 4	10	252.45 ,,	Fine day, glass calm. still from 3 days before.
4	Oct. 9, 1930. 4.00– 5.30 a.m.	17.5°	20.5°	20.8°	20.9°	20.8°	20.7°	20.6°	20.4°	No. 4	—	244.09 ,,	Sunny day, glass calm. still from previous day.
5	Oct. 10, 1930. 8.40– 9.30 a.m.	19.8°	19.9°	—	—	—	—	—	—	No. 5	11	237.95 ,,	Still, sunny.
6	Oct. 24, 1930. 2.30– 3.00 p.m.	19.0°	19.0°	19.5°	19.0°	19.0°	18.8°	18.8°	18.5°	No. 4	12	74.93 ,,	Fine day, still. previous day east breeze.
7	Nov. 9, 1930. 2.00– 3.00 p.m.	16.4°	17.0°	16.9°	16.8°	16.9°	16.5°	16.9°	17.0°	No. 5	9	28.92 ,,	Fine, calm day, still and sunny from 5 days before.
8	Dec. 6, 1930. 10.00–11.00 a.m.	4.5°	12.5°	11.8°	12.5°	—	12.5°	—	12.2°	No. 3	13	41.65 ,,	Calm day. snow storm seneral days before.
9	Jan. 19, 1931. 10.00–11.30 a.m.	-1.3°	6.2°	6.9°	7.1°	7.3°	7.0°	7.3°	8.1°	No. 4	20	15.96 ,,	Ditto.
10	Feb. 28, 1931. 9.00–11.00 a.m.	1.8°	4.8°	5.0°	4.9°	—	4.9°	—	5.0°	No. 4	11	362.70 ,,	Fine day, east breeze. previous day west mind.
11	March 11, 1931. 9.00–11.00 a.m.	-0.4°	6.0°	6.0°	6.1°	—	6.5°	—	6.7°	No. 6	7	529.40 ,,	Calm day, previous day S. W. breeze.
12	Apr. 14, 1931. 9.20–12.00 a.m.	6.1°	6.9°	7.4°	7.1°	—	7.2°	—	7.2°	No. 5	12	311.30 ,,	West breeze.

a comparative study of plankton in Syracuse by using the pump and net. He collected and filtered 75 to 100 litres of water which were collected from the depth of 110 meters from the surface. At the same time he made, too, a net collection and compared both specimens by counting them according to HENSEN's method.

In the present investigation the suction tubing used was 23 mm in diameter, 30 meters in length, consequently having the content of about 11 litres, and was graduated every 1 meter. 30 litres of water were taken from each of the layers of the surface, 2 m, 4 m, 6 m, 8 m, 10 m, 15 m, 20 m, 25 m, and 30 m, excepting in the case of the last observation in which the collections were made from every two meters up to the 30 meter depth. The pumping of 30 litres of water took about 2.5 minutes. In the cases of *Exp.* 9 and 10, the terminal end of the suction tubing was wound at a constant rate so as to suck up the waters of all layerys continuously, thus collecting about 27 litres of water. At the end of the outlet tubing of the pump was attached a small plankton net consisting of 'Müllergaze' No. 25 with a view to filtering the water. The plankton collected in this way was put in a bottle of about 500 cc capacity and to it was added formalin up to 2–3%. After allowing it to settle for 24 hours supernatant water was drained by means of an aspirator, leaving about 100 cc of water. This water with plankton was transferred to a narrow cylinder and superflous water was again drained by the above method. The water and plankton thus condensed were transferred to a graduated cylinder of 25 cc (2 cm in diameter) and after being allowed to settle for 24 hours the volume of plankton was read and recorded. As in the case of HENSEN's investigation (1896, p 138) the vulume of plankton was read after the material had been allowed to settle for 24 hours. Even after more than 24 hours the volume showed a slight decrease with time as was shown by HENSEN and APSTEIN. In our case, however, this decrease was so little as to be almost negligible, showing a decrease of about 3% in 72 hours after the first reading. For the convenience of comparison the volume of plankton thus obtained was converted into the volume per cubic meter of water.

b) COLLECTION BY NET. Two kinds of nets were used. One of them was of common type. On using these nets 1–2 kg of lead were attached to the lower end to make the net sink vertically. The

net thus sunk was wound by means of a simple sounding machine with a speed of 50 cm per second.

NET OF ORDINARY TYPE. This net was 12 cm in diameter, 100 cm in length, consisting of 'Müllergaze' No. 25, and at its lower end was attached a small brass bucket which was provided with a stopcock. The section area of the entrance of this net was about 131.1 sq cm and the filtration surface was about 2000 sq cm, hence the ratio of these two areas was 1 : 17.7. Therefore, when this net was towed 30 meters it passed through a water column of 339 litres volume, though the amount of water actually filtered must have been less than this on account of the resistance of the mesh of the net.

NET OF HENSEN'S TYPE. This net also consisted of 'Müllergaze' of No. 25. Though the diameter of the head piece was almost like that of HENSEN's middle net, other particulars were somewhat modified as can be seen from what follows:

(1) Radius of entrance (r) — 7.0 cm.
(2) Area of the section area of entrance (πr^2) — 154. sq cm.
(3) Radius of widest part (R) — 17.0 cm.
(4) Length (excluding bucket) (L) — 145.0 cm.
(5) Filtration area (area of cone, excluding head piece) — 8668 sq cm.
(6) Ratio of the section area of entrance to the filtration area — 1 : 56.

As the filtration surface was far greater than that of the former net the filtration coefficient was expected to be much smaller than that of the former net. When new the area of the mesh of gauze No. 25 is about 1/4.2 of the total area of the gauze. Therefore if this ratio were assumed to be 1/5, the area of the mesh may be 8668/5 = 1734 sq cm., that is, about 11 times the area of the section area of the entrance. Therefore if the meshes of the net were not choked by the filtration of plankton the water which enterend the net could pass freely. But in fact due to the choking of the mesh the rate of filtration decreases from the moment of commencing the tow. Accordingly, as was indicated by HENSEN (1895, p. 92) the filtration coefficient does not approximate 1.0 unless the filtration area is made extraordinarily large in comparison with the area of entrance. In addition the mesh gradually shrinks with long usage, and further

the speed and distance of towing the net also interfere with the filtration rate. So that the appropriate ratio of the entrance area to the filtration area may only be determined empirically.

(4) RESULTS OF THE INVESTIGATION.

Observation I.

(Aug. 26th 10.00–11.30 a. m. 1930)

The plankton of this collection was dominated by diatoms, of which the main species were listed in the following table. Among these diatoms the prevailing species were *Chaetoceras*, *Rhizosolenia*, and *Hemiaulus*. Although zooplankton played rather a minor part in this season, still several species of Copepods such as *Centropages*, *Euterope*, *Microsetella*, *Oithona*, *Oncaea*, and *Temora* were found. Between the two types of specimens collected by pump and net no distinction has

Species of plankton

Zooplankton.	Phytoplankton.
1. *Centropages kröyeri.*	1. *Biddulphia* sp.
2. *Corycaeus* sp.	2 *Bacteriastrum varians.*
3. *Euterope acutifrons*	3. *Chaetoceras didymum.*
4. *Microsetella norwegica*	4. *Ch. Schüttii.*
5. *Oithona plumifera.*	5. *Ch. decipiens.*
6. *Oncaea venusta.*	6. *Ch. peruvianum.*
7. *Temora discaudata.*	7. *Ch. contortum.*
8. *Penilia schmackeri.*	8. *Ch.* sp.
9. *Copepoda naupli.*	9. *Coscinodiscus lineatus.*
10. Zoea larva.	10. *Coscinodiscus* sp.
11. Polychaeta larva.	11. *Heniaulus* sp.
12. Lamellibranchs larva.	12. *Navicula* sp.
13. Hydromedusa.	13. *Pleurosigma* sp.
14. *Tintinopsis* sp.	14. *Rhizosolenia alata.*
15. *Ceratium pulchellum.*	15. *Rhiz. hebetata f. semispina.*
16. *Ceratium gallicum.*	16. *Rhiz. Stolterfothii.*
17. *Ceratium* sp.	17. *Skeletonema* sp.
18. *Peridinium* sp.	18. *Thalassiothrix Frauenfeldii.*
	19. *Thal'rix nitzschioides.*
	20. *Trochiscia Clevei.*

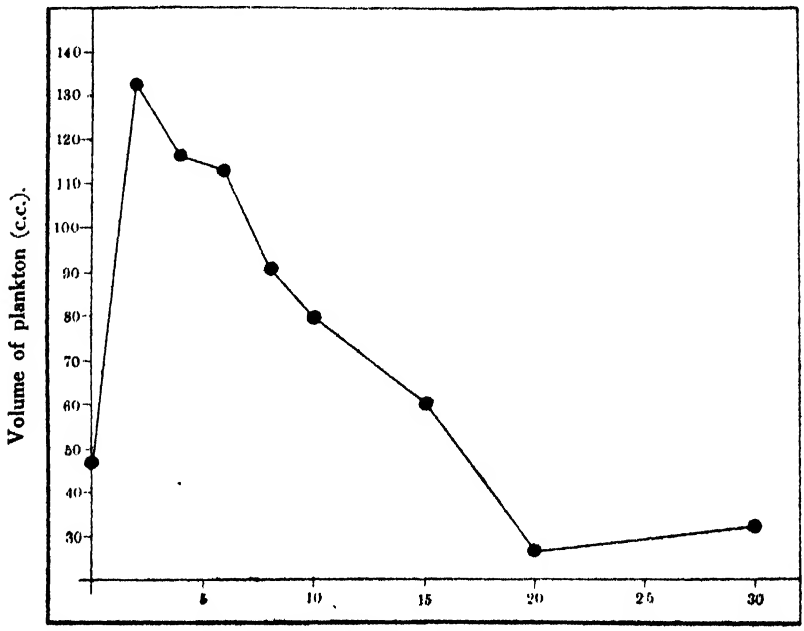
(a) Pump collection.

Depth / Vol. of Pl. (c.c.)	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	30. m.	Mean
Actual catch of net.	1.4	4.0	3.8	3.4	2.8	2.4	1.8	0.8	1.0	2.14
Per cubic m. by conversion.	46.62	133.20	126.54	113.22	91.26	79.92	59.94	26.64	33.33	78.96

(b) Net collection.

Quantity / Dist. of haul	Actual catch	Vol. of water column (l.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
(I) 30 m.→surface.	5.8	339.0	17.1	4.62
(II) 30 m.→surface	5.8	339.0	17.1	4.62

Fig. 1.



been found concerning either species or their morphological condition. Pump collection seems likely to do no harm even to such a delicate

structure as a colony of *Chaetoceras.*

Looking through the specimens collected from different depths it is remarkable that the specimens taken from 2–4 meters showed a voluminous cottony condition while that of 15 meters gave dense deposition, the two differing markedly from each other. On examining these under the microscope it was found that the cottony sediment is composed of *Chaetoceras* and the dense deposit is mainly composed of such spineless diatoms as *Rhizosolenia*, *Biddulphia*, and *Coscinodiscus.* As the specimens collected from below 15 meters were mixed with some debris they looked a little brownish. Among zooplankton, *Copepods* were chiefly found between the 6 and 15 meter layers while *Tintinoidea* and *Lamellibranchs* larvae were found near the bottom.

As will be seen from the results of the pump collections, maximum abundance was found at the depth of 2 meters, showing about 260 cc per cubic meter of water. The minimum amount of 27 cc per cubic meter was found in the depth between 20 and 30 meters. The quantity at the surface is almost the same as that of 22 meters, and an average throughout all depths was shown to be about 79 cc per cubic meter of water.

As the catches of the two vertical collections, hauled from the bottom to the surface (30 meters), averaged 5.8 cc, the quantity of water actually filtered by net was calculated to be 73.4 litres. Comparing this quantity with the volume of the water column (339 litres) which was swept by the net, the filtration coefficient of the net turned out to be 4.62.

Observation II.

(Sept. 11th 1930)

The general features of the plankton of this collection are almost similar to those of the former observation, although the diatom increased in the number of species as well as in quantity. Among the species of diatom *Chaetoceras didymum* showed prominent increase while *Ch. peruvianum* almost disappeared. As regards zooplankton the appearance of *Creseis sp.,* which was not found in the previous observation, was noticeable. *Tintinopsis* and *Ceratium* increased in quantity and also in species.

With regard to vertical distribution, species of *Chaetoceras* crowded the stratum of the upper 15 meters, and hence the specimens collected showed a cottony appearance. From the 20 meter layer downwards, however, the water was crowded mainly by spineless diatoms. Therefore the specimens from these layers gave a fine dense deposit on account of the debris mixed with them and showed a faint brownish tint when preserved. As in the former experiment *Tintinoidea* and *Lamellibranchs* larvae were chiefly found below the 20 meter layer.

(a) Pump collection (3.00–4.00 p.m.).

Depth / Vol. of Pl. (c.c)	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	30. m.	Mean
Actual catch	10.8	10.8	10.4	9.0	7.2	8.6	5.6	3.6	3.6	6.95
Per cublic m. by conversion.	359.64	359.64	346.32	299.70	239.76	286.38	186.48	119.88	119.88	257.52

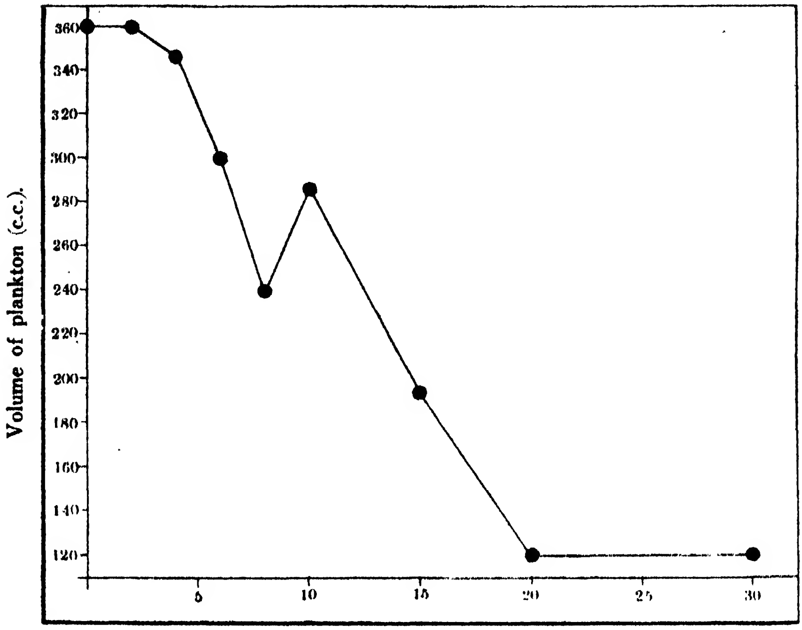
(b) Net collection (net of ordinary type) (3.00 p.m.).

Quantity / Dist. of haul	Vol. of water column. (l.)	I		II		Mean value Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
		Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)		
5. m.→surface	56.5	5.5	97.54	5.0	88.49	92.92	2.76
10. m.→surface	113.0	8.0	70.80	8.8	77.80	74.30	3.47
30. m.→surface	339.0	14.2	41.88	10.2	30.00	35.94	7.17

(c) Net collection (net of ordinary tape) (10.00 a.m.).

Quantity / Dist. of haul	Vol. of water column (l.)	I		II		Mean value Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
		Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)		
5. m.→surface	56.5	5.4	95.5	3.6	63.7	79.6	3.24
10. m.→surface	113.0	6.8	60.1	4.9	43.3	51.7	4.93
30. m.→surface	339.0	11.2	33.0	12.8	37.7	35.4	7.29

Fig. 2.



Depth in meter.

The results of the pump collection show us that the maximum abundance of plankton is found in the stratum of the upper 2 meters layer. From this downwards the quantity decreases with the depth, attaining the minimum between the 20 and 30 meter layers. In this collection the 10 meter stratum yielded more plankton than the 8 meter stratum, showing a little discrepancy. But this may be accounted for as being due to the fact that the diatom which diminished its buoyancy according to physiological faintness, fell from the upper layer and became suspended in the stratum of 10 meters. The quantity of plankton increased as a whole, the mean quantity being 258 cc per cubic meter of water. The maximum and minimum quantities were about 360 cc and 120 cc respectively.

Net collections were made twice, before and after noon, in order to test if the phytoplankton changes its vertical distribution after several hours of carbon assimilation. Comparison of these two collections showed that the quantity of the upper layer is a little larger in the afternoon than in the forenoon, though the distinction is not

very well marked.

The average value of 4 vertical collections made from 30 meters to the surface was 35.7 cc per cubic meter. The filtration coefficient was indicated to be 7.20, as this average catch was about 1/7.20 of the pump catch.

Observation III.

(Sept. 25, 1930)

The phytoplankton which appeared in this collection consisted of about 40 species. A striking alteration in comparison with the former observation lay in the fact that *Chaetoceras didymum* which predominated in the former collection decreased and was replaced by *Ch. Schüttii.* The species which first appeared this time was *Coscinodiscus asteromphalus*, *Asterionella japonica*, and *Nitzschea seriata*. Among zooplankton the *Copepods* which formerly appeared were, too, all found in this collection. Besides these, *Paracalanus pavus* and *Acartia clausi* were frequently found whereas *Labidocera detruncatum* and *Calanus tenuicornis* were rarely found. As regards larval forms, *Aurecularia* and *Trochophora* were common.

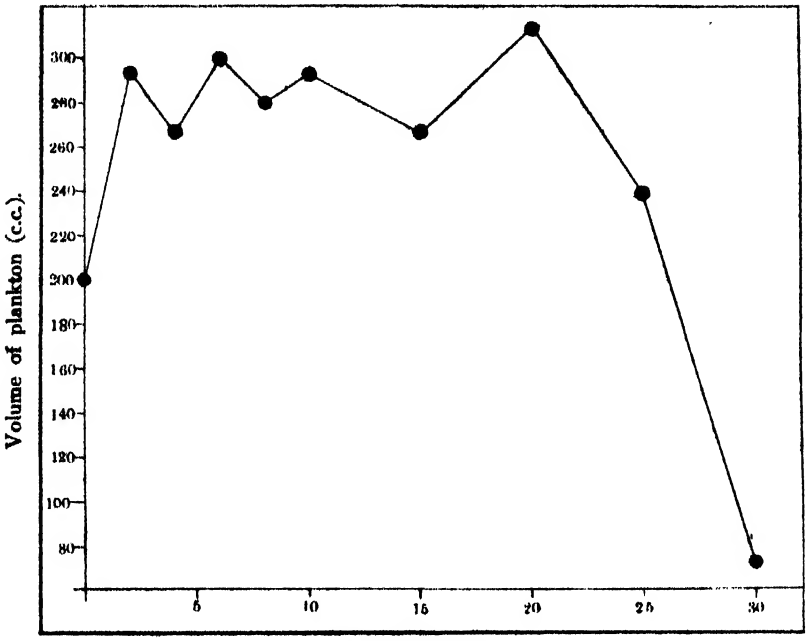
(a) Pump collection (3.00 p.m.)

Depth / Vol. of Pl. (c.c.)	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	6.0	8.8	8.0	9.0	8.4	8.8	8.0	9.4	7.2	2.2	7.58
Per cubic m. by conversion	199.80	293.04	266.40	299.70	279.72	293.04	266.40	313.02	239.76	73.26	252.45

(b) Net collection (net of ordinary type) (3.00 p.m.)

Quantity / Dist. of haul	Vol. of water column. (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
(I) 30. m.→surface	339.0	9.8	28.90	8.76
(II) 30. m.→surface	339.0	8.4	24.77	10.21
Mean Value	339.0	9.1	26.84	9.48

Fig. 3.



Depth in meter.

The specimens from 30 meters upwards were closely allied to one another, chiefly consisting of *Chaetoceras*. But at the 30 meter layer *Chaetoceras* decreased more or less, minute debris increasing. Among zooplankton, *Copepods* were scanty in the layer from 4 meters upwards.

According to the results of the pump collection, the distribution differs a little from that of the former observation, viz., it became somewhat homogeneous throughout the whole layer. The stratum of maximum abundance was found in the 20 meter depth, and distinct decrease was found from 25 meters downwards. The mean quantity per cubic meter was 253 cc, showing no pronounced difference from the former observation.

The catch of net collection was 27 cc in mean, corresponding to about 1/9.42 of the pump catch, consequently the filtration coefficient in this case was determined to be 9.42.

Observation IV.

(Oct. 9th, 1930)

In this observation, too, about 40 species of diatoms, among which *Chaetoceras Schüttii* predominated, were found. Zooplankton consisted chiefly of *Copepods*, especially of *Acartia clausi*. As to vertical distri-

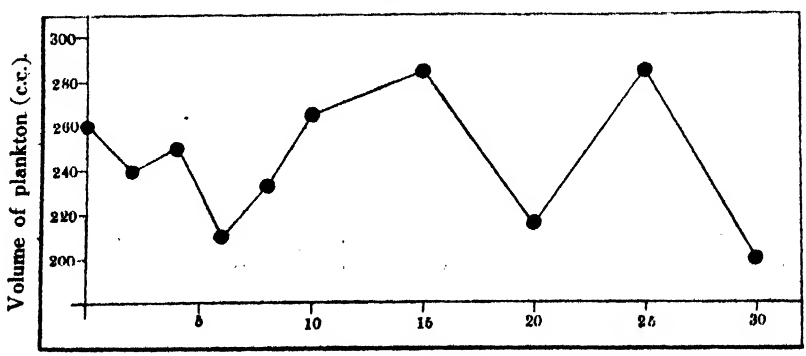
(a) Pump collection (4.00-5.30 p.m.)

Depth / Vol. of Pl. (c.c.)	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	7.8	7.2	7.5	6.3	7.0	8.0	8.5	6.5	8.5	6.0	7.33
Per cubic m. by conversion	259.74	239.76	249.75	209.76	233.10	266.40	283.05	216.45	283.05	199.80	244.09

(b) Net collection (net of ordinary type) (5.15-5.40 a.m.)

Quantity / Dist. of haul	Vol. of water column. (l.)	I		II		Mean value Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
		Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)		
5. m.→surface	56.5	4.2	74.33	3.3	58.40	66.36	3.72
15. m.→surface	169.5	9.5	56.00	6.5	38.34	47.17	5.17
30. m.→surface	339.0	16.0	47.19	13.0	38.34	42.76	5.70

Fig. 4.



Depth in meter.

bution it was observed that *Chaetoceras* was distributed from the surface to the 20 meter depth. From 20 meters downwards, however, this species tended to decrease, being replaced by *Thalassiothrix Frauenfeldii*. As was the case with the former observation, debris increased as the depth approached the bottom.

The present observation was carried out prior to sunrise in order to observe the distribution of phytoplankton before it commences assimilation. As will be seen in the above table, the result shows that the distribution is more or less homogenous and the quantity of plankton ranged between 200 and 280 cc throughout the whole layer. The mean quantity throughout all depths showed 244 cc per cubic meter, and the maximum and minimum values were 283 and 200 cc respectively.

Net collections which were made twice vertically from the bottom to the surface showed the mean catch to be 42.70 cc per cubic meter. This quantity corresponds to about 1/5.71 of the pump catch, and hence the filtration coefficient was indicated to be 5.71.

Observation V.

(Oct. 10th, 1930)

The species found in this collection closely resembled those of the former observation. The vertical distribution was also well allied to that of the former observation.

To solve the question as to whether the vertical distribution of phytoplankton shows any change according to the diurnal change of illumination, two collections, one taken before- and one afternoon of a sunny day, Oct. 10th, were compared.

By the pump collection made in the forenoon the maximum

(a, 1) Pump collection (8.40–9.30 a.m.).

Depth / Vol. of Pl. (c.c.)	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	8.6	9.5	8.0	8.0	8.5	6.5	7.0	6.5	4.7	5.8	7.31
Per cubic m. by conversion	286.38	316.15	266.40	266.40	283.05	216.45	233.10	216.45	156.51	193.14	243.40

(a, 2) Pump collection (2.30–3.30 p.m.).

Vol. of Pl. (c.c.) \ Depth	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	6.0	7.5	7.4	8.4	7.5	8.2	8.5	6.0	6.4	5.0	7.09
Per cubic m. by conversion	199.80	249.75	246.42	279.72	243.75	273.06	283.05	199.80	213.12	166.50	232.50

(b, 1) Net collection (net of ordinary type) (8.40–9.30 a.m.).

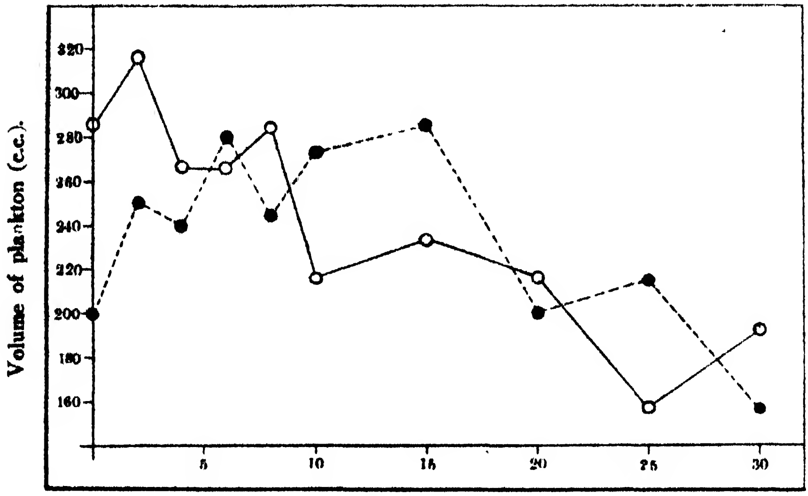
Dist. of haul \ Quantity	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
5. m.→surface	56.5	4.0	70.70	4.09
15. m.→surface	169.5	10.0	58.90	4.52
30. m.→surface	339.0	14.5	42.77	5.68

(b, 2) Net collection (net of ordinary type) (2.30–3.30 p.m.).

Dist. of haul \ Quantity	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
5. m.→surface	56.5	3.0	53.0	4.38
15. m.→surface	169.5	8.0	47.0	5.38
30. m.→surface	339.0	11.6	34.2	6.80

abundance was found in the 2 meter depth. From this downwards, the quantity decreased with the depth, though the mode of decrease was not so prompt as that in Obs. I–III. Contrasted with such distribution, the collection of the afternoon showed a decrease of plankton in the upper five meter stratum while it increased from the five meter depth downward. The fact that in the 1 meter layer the quantity was less than in the 2 meter layer was common to both collections. The quantity of plankton per cubic meter was 243 cc in the forenoon and 232 cc in the afternoon. The difference of about 5% found here may probably be due to investigational error. In

Fig. 5.



short, so far as the present observation are concerned, no pronounced alteration of distribution was found from forenoon to afternoon. Accordingly we are led to suggest that there may be no change of vertical distribution due to the change of intensity of light.

As for the net collection, it was found that in the forenoon as well as in the afternoon the abundance of plankton was higher in the upper layers than in the lower layers. If there were any change in distribution in the upper layer, the proportion of the catch of the five meter collection to that of the 15 meter collection would have altered from forenoon to afternoon. Actually, however, no such change has been observed, and this ratio (1 : 1.2) remained unchanged until afternoon. Therefore it follows that the change of distribution, which is found to occur in the upper five meters as estimated by the pump has not been detected by net collection. Two net collections of 30 meters from bottom to surface averaged 38.5 cc per cubic meter through fore- and afternoon. As this quantity corresponds to about 1/6.2 of the mean catch (238 cc per cubic meter) the filtration coefficient turned out to be 6.20.

Observation VI.

(Oct. 24th, 1930)

The species which showed special prominence in this observation were *Thalassiothrix Frauenfeldii* and *Thal'rix nitzschioides*. *Asterionella japonica* was the next in abundance. Among the genus *Chaetoceras Ch. Schüttii*, *Ch. decipiens*, *Ch. debile*, and *Ch. criophilum* were fairly commonly found, though the quantity was less than these in the former observation. *Bacteriastrum varians*, *Rhizosolenia Stolterfothii*, and *Nitzschia seriata* were also found. Zooplankton consisted chiefly of *Copepods* especially of *Paracalanus pavus* and *Oithona similis*. *Nauplius* of *Copepoda* and larvae of *Lamellibranchs* were also found.

As the species which comprised the bulk of the catch were the diatoms other than *Chaetoceras*, the specimens gave a dense deposit instead of a voluminous cottony sedimentation. Due to the addition of debris the catch from 10 meters downwards showed a faint brownish tint after preservation, and this was especially so with the specimens collected from 30 meters.

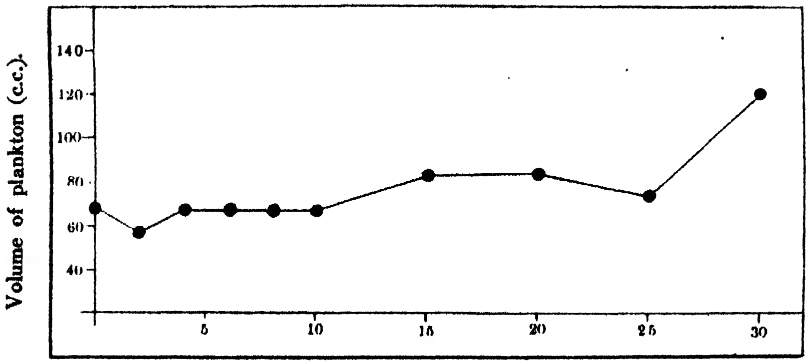
(a) Pump collection (2.00–3.00 p.m.).

Depth / Vol. of Pl. (c.c.)	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	2.0	1.7	2.0	2.0	2.0	2.0	2.5	2.5	2.2	3.6	2.25
Per cubic m. by conversion	66.60	56.61	66.60	66.60	66.60	66.60	83.25	83.25	73.26	119.88	74.93

(b) Net collection (net of ordinary type) (3.00–3.05 p.m.)

Quantity / Dist. of haul	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
5. m.→surface	56.5	1.0	17.60	3.58
15. m.→surface	169.5	2.0	11.80	5.73
30. m.→surface	339.0	3.3	9.73	4.93

Fig. 6.



Depth in meter.

As the above figure shows, the vertical distribution at the time of this experiment indicates a tendency for the plankton to increase in abundance with the depth, reaching the maximum at the depth of 30 meters. Such a mode of distribution was first observed in the present observation and was quite opposed to the distribution hitherto observed. In regard to this point further comment will be given later. The quantity of plankton per cubic meter of water averaged 74.93 cc, showing as much abundance as 1/3 of that of the former observation.

The catch of the net collection hauled up from 30 meters to the surface showed the quantity per cubic meter to be 9.73 cc, viz., about 1/7.7 of the catch of the net collection.

Observation VII.

(Nov. 9, 1930)

The general features of the plankton in this observation show some resemblance to those of the former. The species which comprise the majority of the catch are the diatoms, *Thalassiothrix nitzschioides* and *Biddulphia sinensis*. Several species of *Chaetoceras* and *Rhizosolenia sp.* were next in abundance. *Asterionella japonica*, which predominated in the former observation, decreased markedly. Among zooplankton, nauplius of *Copepoda* was predominating, followed in turn by *Oithona sp.*, *Ceratium sp.*, and *Oikopleura sp.*

Comparing the specimens from the surface with those from the

30 meter depth, it is noticeable that *Thalassiothrix nitzschioides* was found prevailingly at the surface; at 30 meters, however, the *Ch. decipiens* was found to be increased almost as much as the preceding species. *Biddulphia sinensis* and *Asterionella japonica* were evenly distributed throughout the whole layer.

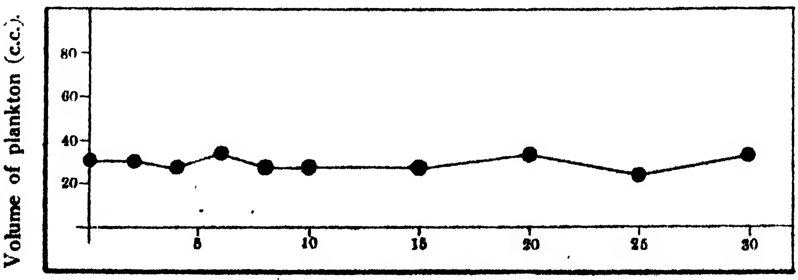
(a) Pump collection (2.00–3.00 p.m.).

Vol. of Pl. (c.c.) \ Depth	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	0.9	0.9	0.8	1.0	0.8	0.8	0.8	1.0	0.7	1.0	0.87
Per cubic m. by conversion	29.97	29.97	26.64	33.33	26.64	26.64	26.64	33.33	23.31	33.33	28.97

(b) Net collection (net of ordinary type) (2.00–3.00 a.m.).

Dist. of haul \ Quantity	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
5. m.→surface	56.5	0.4	7.80	4.06
10. m.→surface	169.5	0.8	4.71	6.05
30. m.→surface	339.0	1.5	4.41	6.55

Fig. 7.



Depth in meter.

The results of the pump collection show that the quantity of plankton is distributed very evenly from the surface to the bottom. The quantity per cubic meter was 28.97 cc in average, viz., about 1/2.6 of the catch of the preceding observation (75 cc per cubic meter).

The net collection hauled from the 30 meter depth showed its catch to be 4.41 cc per cubic meter, that is, about 1/6.65 of the pump catch.

Observation VIII.

(Dec. 6th, 1930)

According to their relative abundance the species which appeared in the present observation can be ranked as in the following table. ***Biddulphia sinensis*** which already showed an increasing tendency in the former observation became the commonest species in the present catch. *Thalassiothrix nitzschioides* was also commonly found. Zoo-plankton chiefly consisted of naupli of *Copepods*, *Acartia clausi*, *Oithona sp.*, *Distephanus speculum*, *Tintinopsis sp.*, etc. The other catch, which was separately made by using a large plankton net, indicated the presence of fifteen or more species of *Copepods*, three species of *Phyllopoda*, *Muggiaea atlantica*, *Obelia sp.*, and many other larval forms.

Due to the scantiness of *Chaetoceras*, the specimen deposited densely. The debris was found from the 2 meter layer, increasing especially from 10 meters downwards. No difference was found

Species of Phytoplankton.	Species of Phytoplankton.
1. *Biddulphia sinensis.*	16. *Eucampia zoodiacus.*
2. *Thalassiothrix nitzschioides.*	17. *Pleurosigma* sp.
3. *Thal'rix furvata.*	18. *Chaetoceras contortum.*
4. *Biddulphia longicrusis.*	19. *Ch. sociale.*
5. *Chaetoceras decipiens.*	20. *Thalassiothrix longissima.*
6. *Asterionella japonica.*	21. *Thal'rix Frauenfeldii.*
7. *Chaetoceras* sp.	22. *Nitzschia seriata.*
8. *Ch. debile.*	23. *Hémiaulus* sp.
9. *Bacteriastrum* sp.	24. *Chaetoceras didymum.*
10. *Coscinodiscus* sp.	25. *Paralia* sp.
11. *Rhizosolenia Stolterfothii.*	26. *Ditylium Brightwellii.*
12. *Rhiz. imbricata* var. *shrubsolei.*	27. *Planktoniella sol.*
13. *Corethron criophilum.*	28. *Rhizosolenia semispina.*
14. *Chaetoceras Schüttii.*	29. *Chaetoceras diadema.*
15. *Thalassiosira* sp.	30. *Climacodium* sp.

between the surface specimens and 30 meter specimens except the slight increase of *Thal'rix nitzschioides* with depth.

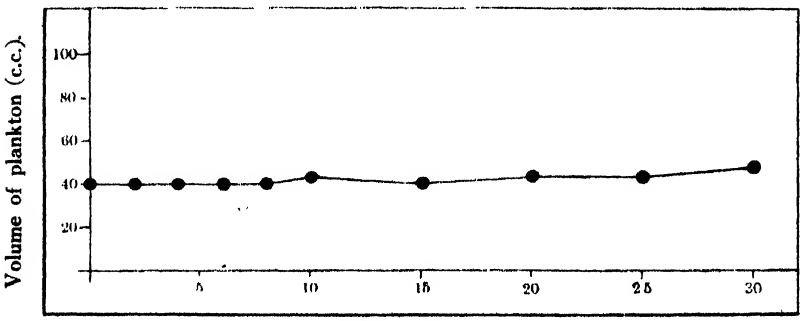
(a) Pump collection (10.17–10.46 a.m.).

Depth / Vol. of Pl. (c.c.)	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3	1.3	1.4	1.25
Per cubic m. by conversion	40.0	40.0	40.0	40.0	40.0	43.3	40.0	43.3	43.3	46.6	41.65

(b) Net collection (net of ordinary type) (10.50–10.58 a.m.).

Quantity / Dist. of haul	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
5 m.→surface	56.5	0.5	8.85	4.52
15. m.→surface	169.5	0.8	4.72	8.56
30. m.→surface	339.0	1.4	4.13	10.08

Fig. 8.



Depth in meter.

The results of this observation are just like those of the preceding one. The vertical distribution was very homogeneous. The quantity of plankton per cubic meter averaged 41.65 cc, corresponding to about 1/10 of the pump collection.

Observation IX.

(Jan. 19th, 1931)

The dominating species in the present collection were three species of *Coscinodiscus*, namely *Cos. asteromphalus*, *Cosc. Janischii*, and another unidentified species. *Biddulphia sinensis* which comprised the greater part of the catch of the former observation decreased greatly. *Chaetoceras debile*, as will be found from the next observation, showed no change after December. Regarding vertical distribution, it was found that *Chaetoceras debile* crowded the upper layers more densely than the lower layers.

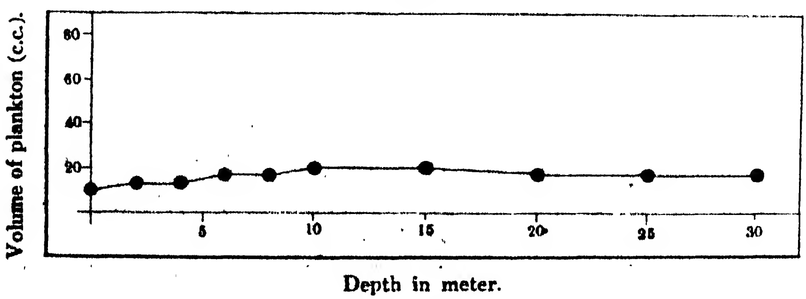
(a) Pump collection (10.00–11.30 a.m.).

Depth / Vol. of Pl. (c.c.)	Surface	2. m.	4. m.	6. m.	8. m.	10. m	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.48
Per cubic m. by conversion	10.0	13.3	13.3	16.6	16.6	20.0	20.0	16.6	16.6	16.6	15.96

(b) Net collection (net of ordinary type) (11.25–11.45 a.m.).

Quantity / Dist. of haul	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
5. m.→surface	56.5	0.2	3.54	3.45
5. m.→surface	56.5	0.2	3.54	3.45
15. m.→surface	169.5	0.5	2.95	5.28
15. m.→surface	169.5	0.4	2.36	6.62
30. m.→surface	339.0	0.7	2.06	7.74
30. m.→surface	339.0	0.7	2.06	7.74

Fig. 9.



The vertical distribution is homogeneous throughout the whole layer. It was remarkable that in this season the plankton probably showed minimum abundance, giving only 15.96 cc per cubic meter of water. The average catch of the net collections of 30 meters was about 1/7.74 of the amount of the pump collection. The four catches of 15 meter collection varied greatly from haul to haul, averaging 3.1 cc per cubic meter of water.

Observation X.

(Feb. 28, 1931)

Among the diatoms which predominatingly comprised the present catch, the main species are listed below according to their relative abundance. Regarding the species, one will notice distinct alteration in comparison to the results of the former observation. For instance, *Biddulphia sinensis* and *Talassiothrix nitzschioides*, which were found until the time of the previous observation, have almost disappeared. *Chaetoceras debile* showed special prominence anew, *Coscinodiscus asteromphalus* was the next in abundance. Among zooplankton *Parafavella* showed a maximum occurence. *Oikopleura sp.* and species of Ceratium were found fairly frequently.

Species of phytoplankton.	Species of phytoplankton.
1. *Chaetoceras debile.*	11. *Nitzschia seriata.*
2. *Coscinodiscus asteromphalus.*	12. *Chaetoceras Schüttii.*
3. *Thalassiothrix* sp.	13. *Coscinodiscus Janischii.*
4. *Chaetoceras atlanticum.*	14. *Thalassiothrix nitzschioides.*
5. *Chaetoceras* sp.	15. *Rhizosolenia setigera.*
6. *Asterionella japonica.*	16. *Pleurosigma* sp.
7. *Chaetoceras sociale.*	17. *Fragilaria* sp.
8. *Thalassiothrix longissima.*	18. *Chaetoceras decipiens.*
9. *Chaetoceras boreale.*	19. *Ditylium Brightwellii.*
10. *Chaetoceras criophilum.*	

The method of pump collection of this observation differed from that of the former observation in the point that in this observation 26.6 litres of water were collected continuously from 30 meters to the surface by winding the terminal end of the suction tubing at a

(a) Pump collection (10.10–10.30 a.m.).

Quantity / Dist. of haul	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Mean value Vol. of Pl. per cubic m. (c.c.)
15. m.→surface	14.5	5.0	344.8	337.9
15. m.→surface	14.5	4.8	331.0	
30. m.→surface	26.6	9.8	368.4	362.7
30. m.→surface	26.6	9.5	357.1	

(b) Net collection (net of Hensen's type) (9.30–10.00 a.m.).

Quantity / Dist. of haul	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
15. m.→surface	231.0	34.5	149.3	2.66
15. m.→surface	231.0	26.0	112.5	3.00
15. m.→surface	231.0	30.5	132.0	2.56
15. m.→surface	231.0	30.2	130.7	2.58
15. m.→surface	231.0	26.7	115.5	2.92
30. m.→surface	462.0	38.5	83.3	4.35
30. m.→surface	462.0	42.5	91.9	3.94

(c) Net collection (Net of ordinary type) (10.40–11.00 a.m.).

Quantity / Dist. of haul	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
15. m.→surface	169.5	10.1	59.5	5.68
15. m.→surface	169.5	9.5	56.0	6.03
30. m.→surface	339.0	15.5	45.7	7.93
30. m.→surface	339.0	15.0	44.2	8.20

constant rate, instead of taking each 30 litres of water from different depths separately. According to this method plankton abundance averaged 362 cc per cubic meter, showing a great increase in comparison to the former observation.

The collections of the 30 meter haul made by the net of Hensen's type averaged 87.6 cc per cubic meter. As this quantity is about 1/4.14 of the pump catch the filtration coefficient was indicated to be 4.14. But the catch of the 15 meter collection is far greater

than the catch of the 30 meter collection, averaging 128 cc per cubic meter, viz., 1/2.84 of the quantity of the pump collection. Comparing these two collections one will notice that the filtration coefficient is proportional to the distance of collection. This is because the greater the water volume filtered, the more the net mesh may become choked. Therefore a mere comparison of the catches of the above two collections does not show any actual quantitative picture, but only shows that the rate of filtration decreases with the distance of the haul.

With the net of ordinary type, too, a similar relation was found, except that the filtration coefficient of this net is by far larger than that of the net of HENSEN's type. A thirty meter haul of this net averaged 45 cc per cubic meter of water. This volume is about 1/8.06 of the pump catch, while the fifteen meter haul showed this quantity to be 57.5 cc, that is, about 1/6.31 of the pump catch. Therefore the relation that the rate of filtration decreases with the increase of the distance of collection was clearly shown.

As the above results show, the filtration coefficient of the net of HENSEN's type is distinctly smaller than that of the net of ordinary type. But as the coefficient of the former as well as the latter varies with the distance of haul it can not be employed for the collection of different depths, unless the coefficient be calculated for each distance.

Observation XI.

(March 11, 1931)

As in the case of the former observation, the bulk of the catch consisted of *Chaetoceras debile*. *Chaetoceras sociale* and other species of the same genus were next in abundance. *Asterionella japonica*, *Coscinodiscus asteromphalus* and fifteen other species were commonly found. Species of zooplankton were almost similar to that of the former observation.

In the present observation, two different net collections were made. In the first of these (a) each 30 litres of water was pumped separately from different depths with the average of 520.6 cc per cubic meter. While in the second collection (b) about 13–29 litres of water were taken continuously from the 15 or 30 meter depths up to the surface

(a) Pump collection (9.30–10.10 a.m.)

Vol. of Pl. (c.c.) \ Depth	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	15. m.	20. m.	25. m.	30. m.	Mean
Actual catch	14.2	14.5	16.0	15.0	14.2	14.0	13.2	16.8	16.5	21.8	15.62
Per cubic m. by conversion	473.3	483.3	533.3	500.0	473.3	466.6	440.0	560.0	550.0	726.6	520.6

(b) Pump collection (9.50-10.10 a.m.).

Dist. of haul \ Quantity	Vol. of water (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Mean value Vol. of Pl. per cubic m. (c.c.)
15. m.→surface	12.6	6.4	507.9	442.3
15. m.→surface	14.6	5.5	376.7	
30. m.→serface	26.8	14.6	544.7	533.7
30. m.→surface	28.7	15.0	522.6	

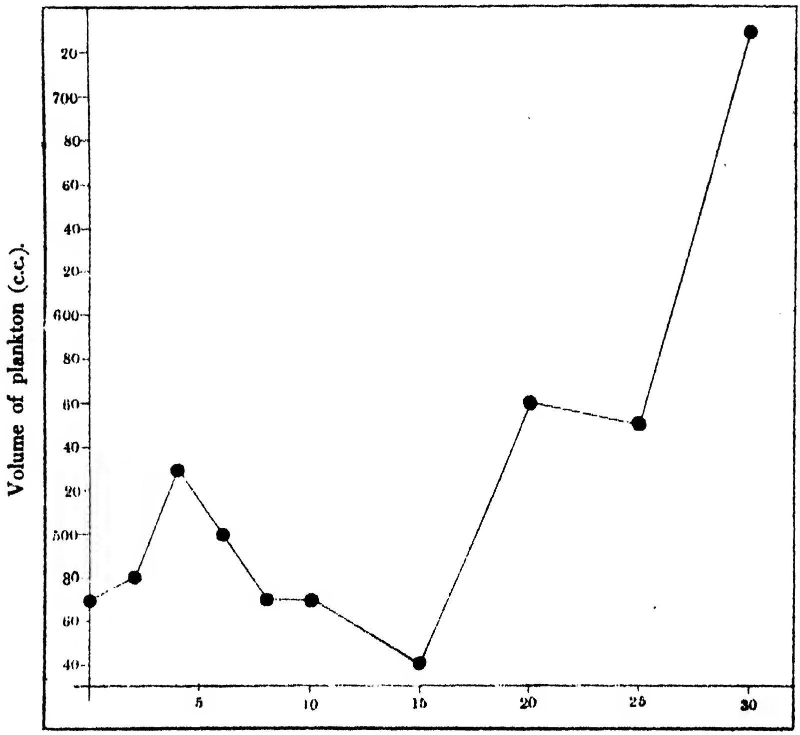
(c) Net collection (net of HENSEN's type) (10.10–10.40 a.m.).

Dist. of haul \ Quantity	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
15. m.→surface	231.0	25.0	108.0	4.08
15. m.→surface	231.0	19.5	84.4	5.25
15. m.→surface	231.0	19.8	85.7	5.16
15. m.→surface	231.0	20.0	86.5	5.11
15. m.→surface	231.0	14.0	60.6	7.31
30. m.→surface	462.0	37.0	80.0	6.66
30. m.→surface	462.0	37.0	80.0	6.66

(d) Net collection (net of ordinary type) (10.20–10.40 a.m.).

Dist. of haul \ Quantity	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
15. m.→surface	169.5	7.8	46.0	9.63
15. m.→surface	169.5	8.0	47.1	9.41
30. m.→surface	339.0	16.5	48.6	10.90
30. m.→surface	339.0	14.0	41.2	12.90

Fig. 10.



Depth in meter.

with the resultant average of 533.7 cc per cubic meter. Combination of these results gives an average value of 527.2 cc per cubic meter. As will be seen in the above table (b) the mean value of the collection of the upper 15 meters (442.3 cc) is less than that of the 30 meter collection (533.7 cc). This is because the abundance of plankton in the lower layer is greater than in the upper layer.

The greater abundance of the plankton in the lower layer than in the upper layer may be seen from table (a) or Fig. 10. The maximum quantity of 726.6 cc per cubic meter was found in the 30 meter layer. Throughout the duration of the present investigation such prominent abundance has not been found elsewhere, so that this may be the vernal maximum vegetation of this year.

It is remarkable that the vertical distribution which has been fairly

homogeneous since Oct. 24 is now altered, showing greatest abundance in the lowermost layer. Such change of distribution might probably be attributed to the fact that the vegetation which attained its maximum at the upper layer sank, weakened according to the change of external (or environmental) or internal (or physiological) conditions, thus crowding the lower layer.

The catch of the 30 meter collection, carried out by using the net of HENSEN's type, averaged 80 cc per cubic meter, viz., 1/6.67 of the catch of the pump collection. The catch of the 15 meter collection averaged 85.14 cc per cubic meter, that is, about 1/5.21 of the catch of the pump collection. Therefore the abundance in the upper layer is seemingly greater than in the lower layer and seems as if it is opposed to the result of the pump collection. But as was stated in the former observation, this may also be due to the increase of filtration coefficient on account of the greater abundance of plankton in the lowest layer.

As regards the collection at 30 meters made by the net of ordinary type, the catch was shown to be 44.9 cc per cubic meter, i. e., about 1/11.89 of the pump collection. In the case of the 15 meter haul the catch (46.1 cc) per cubic meter showed a slight increase as was the case with the collection with the net of HENSEN's type, and consequently the filtration coefficient decreased, proving to be 11.58.

Observation XII.

(Apr. 14th, 1931)

The general features of the plankton in the present observation were almost the same as those of the former observation.

In this experiment water was pumped from the depth of every 2 meters down to 30 meters with the object of determining the vertical distribution in particular. The results thus obtained show some irregularity, indicating that the abundance was highest at the layer of 8 meters and from the layer of 22 meter downwards.

The quantity of plankton measured by the pump method was shown to be 311.3 cc per cubic meter of water. Although this quantity shows some decrease in comparison to that of the former observation, yet it shows well the vestige of the vernal flowering of the diatom.

Collections with the net of HENSEN's type were also made more

(a) Pump collection (9.30–10.40 a.m.).

Vol. of Pl. (c.c.) \ Depth	Surface	2. m.	4. m.	6. m.	8. m.	10. m.	12. m.	14. m.	16. m.
Actual catch	4.5	7.5	8.7	10.0	12.3	9.2	9.0	7.5	6.4
Per cubic m. by conversion	150.0	250.0	290.0	333.3	410.0	307.0	300.0	250.0	213.0

Vol. of Pl. (c.c.) \ Depth	18. m.	20. m.	22. m.	24. m.	26. m.	28. m.	30. m.	Mean
Actual catch	7.0	9.2	11.8	11.5	11.5	11.5	12.0	
Per cubic m. by conversion	230.0	307.0	393.0	383.0	383.0	383.0	400.0	311.3

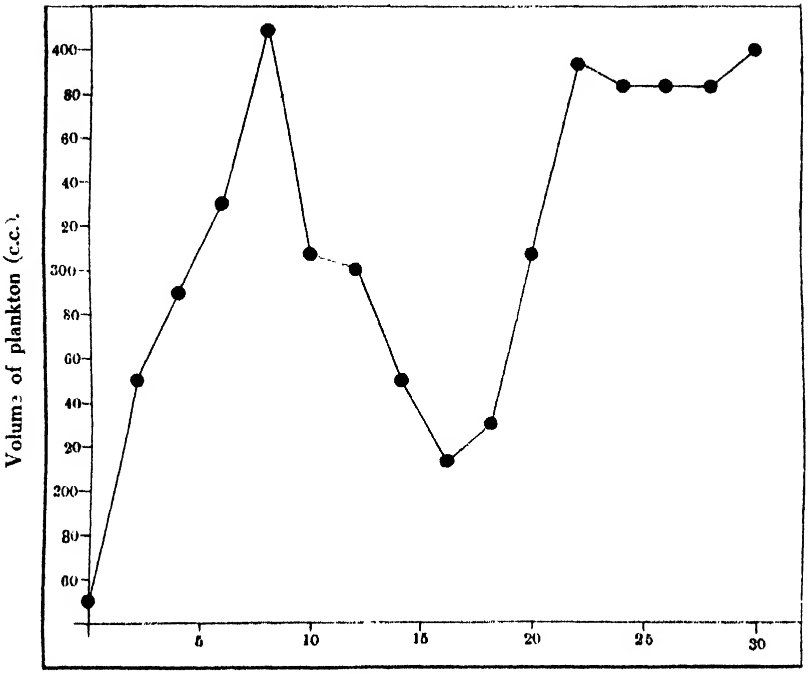
(b) Net collection (net of HENSEN's type) (10.50–11.25 a.m.).

Dist. of haul \ Quantity	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
4. m.→surface	61.6	9.0	146.1	1.57
8. m.→surface	123.4	14.0	113.4	2.52
12. m.→surface	184.4	15.0	81.2	3.24
16. m.→surface	246.4	16.0	64.9	4.29
20. m.→surface	308.0	12.7	41.3	6.70
24. m.→surface	369.6	15.6	42.2	6.95
26. m.→surface	400.4	17.0	42.0	7.06
30. m.→surface	463.0	15.0	32.4	9.67

(c) Net collection (net of ordinary type) (11.30–11.40 a.m.).

Dist. of haul \ Quantity	Vol. of water column (l.)	Actual catch (c.c.)	Vol. of Pl. per cubic m. (c.c.)	Filt. coeff.
5. m.→surface	56.6	3.5	61.9	3.71
15. m.→surface	169.5	5.5	32.4	8.60
30. m.→surface	339.0	8.4	24.8	12.60

Fig. 11.



Depth in meter.

particuarly than in any of the former observation by hauling the net 8 times vertically up to the surface, each haul differing by 4 meters in distance of collection. As will be seen from the table (b), the difference of plankton quantity in every catch is distinct so far as concerns the collection of the upper layer where the abundance alters greatly with the depth. But with the increase of the depth of haul, say over 20 meters, the results become very irregular and show apparent discrepancy. The fact that the filtration coefficient increases with the depth of collection may be obviously seen from the above table (b). In the collection from 4 meters upwards, the coefficient is calculated to be 1.57, showing an approximation to that of HENSEN's middle net in which the coefficient is about 1.40, while in the collections from the depth of 30 meters to the surface the coefficient became about 6.2 times as much as in the former case. Therefore to convert each catch into its true value the coefficient must be altered corres-

ponding to the depth of collection. Regarding the result of the collection made by the net of ordinary type a like tendency was observed excepting that the coefficient is greater by far in this case than in the former case.

5) GENERAL REMARKS.

a) Vertical distribution.

According to APSTEIN (1896) the phytoplankton of the North Sea, especially the diatoms, shows maximum abundance in the layer between the 0 meter and the 5 meter depth though in some case they concentrate evenly from the 0 up to the 50 meter stratum as much as in the uppermost layer. LOHMANN's experiment (1903) which was carried out off Syracuse in the Mediterranean Sea shows that the highest abundance exists in the layer between the 50 and 70 meter levels. GRAN (1909), however, pointed out that in the Norwegian Sea in the begining of summer diatoms concentrate in the layer from 0 meter to 20 meters, extending however to the 50 to 80 meter depth by autumn when the water is warmed down to these depths.

ALLEN (1928) studied the marine diatom catches of South California waters and found a strong indication that the maximum production of diatoms lies at levels of 15 to 30 meters below the surface in summer, while BIGELOW and LESLIE (1930) reported that in Montrey Bay in July 1928 the chief production of diatom took place between the 10 meter level and the surface. Furthermore from APSTEIN's results (1896), obtained from the investigation of 'Plönersee', the diatoms, *Asterionella* and *Merosira* crowd the layer between 0 and 1 meter most densely. At any rate, all these results seem to unite to suggest to us the possibility of some distinct vertical distribution even in shallow water like our bay.

Turning now to the results of our investigation in which twelve observations were made, the first two observations (Aug.–Sept.) show clearly that the abundance of plankton is highest in the upper layer and decreases by degrees with depth. In three subsequent observations (Sept.–Oct.), however, the distribution tended to become somewhat homogeneous from the surface to the lower layer. And in the suceeding four observations (Oct.–Jan.) the distribution became really homogeneous throughout the whole layer. In one observation which

was made on Feb. 28th the pump collection was made in a different way, so that vertical distribution was not observed. But the results of the last two observations (March–Apr.) roughly show a tendency that the lower stratum is more concentrated than the upper stratum. Therefore, so far as the present observations are concerned, the general trend of the vertical distribution is likely to be that in summer the abundance is highest in the upper layer and that it decreases with the depth. But with the advance of the season the distribution becomes homogeneous from the surface to the bottom. After the continuance of such conditions till January or probably till the end of February the vertical distribution becomes inverted, showing higher concentration in the lower stratum than in the upper stratum.

From what has been so far described we are now reminded of GRAN's statement above referred to, in which a like change of vertical distribution due to seasonal changes is suggested. As to why the highest abundance is transferred to the lower stratum during March and April no certain proof was obtained. But the probablity is that on account of the rapid multiplication of diatom there occured some unfavourable condition in the water, such as shortness of nutriment, etc. Because of the decadence thus produced the phytoplankton might have sunk and crowded the lower stratum. As to the homogeneous distribution of winter there is a possibility that it may be caused by the disturbance of the sea due to the strong west wind which prevails during this season. But as all the experiments were made after there had been at least 24 hours of calm conditions the influence of the wind might have been fully neglected. This relation was demonstrated by the fact that even in Obs. VII, which was made after five still days, the distribution was likewise homogeneous, without showing any indication of concentration of plankton in the upper layer.

b) Quantity of plankton.

From the results of pump collection the quantity of plankton per cubic meter of water, during the present experiment, was found to vary with the season as was shown in the following table:

Date (1930–1931)		No. Obs.	Plankton (cc)	
			Each coll.	Monthly ave.
1930	Aug. 26.	I.	78.96	78.96
	Sept. 11.	II.	257.52	254.98
	Sept. 25.	III.	252.45	
	Oct. 9.	IV.	244.90	185.66
	Oct. 10.	V.	237.95	
	Oct. 24.	VI.	74.93	
	Nov. 9.	VII.	28.92	28.92
	Dec. 6.	VIII.	41.65	41.65
1931	Jan. 19.	IX.	15.96	15.96
	Feb 28.	X.	362.70	362.70
	March 11.	XI.	529.40	529.40
	Apr. 14.	XII.	311.30	311.30
(Anual mean)				201.08

Casting a glance at the above table one will be struck by the fact that the low abundance of the plankton of August began to increase from September on. After attaining the so called harvest maximum in September it showed a sudden decrease from the end of October and showed lowest abundance in January. From February, however, there occured a prominent increase, giving rise to the so called vernal maximum, and this shows the greatest abundance of the year. Though the vernal flourishing continued till the middle of April a decreasing tendency was observed from this time on. Contrasted with the vernal multiplication the harvest propagation was less flourishing in so far as the data of the present investigation are concerned.

Basing our results on the above enumerated figures we may deduce a short account concerning the productivity of the plankton in our bay. Since the depth of the station of observation was thirty one meters it follows that 1 square meter of this area yields 495 cc in minimum, 16411 cc in maximum, and 6234 cc in average. But the quantity of plankton in one cubic meter of water shows more extreme alteration when it is considered through all the seasons and all depths. For instance in the Obs. VII (Jan. 19th) surface water gives only

10 cc of plankton per cubic meter, while the 30 meter stratum of Obs. XI (March 11th) gives so much as 726.6 cc per cubic meter.

According to APSTEIN's investigation (1906) the maximum quantity of plankton of 'Ostsee' from February to November (1903) was found on March 8th, and yielded 8320 cc per square meter of the area which measured 33 meters in depth. The minimum quantity in his investigation was found on November 16th, giving 24 cc per square meter. Comparing these values to those of Aomori Bay we notice that Aomori Bay is much richer in plankton than 'Ostsee'. APSTEIN's results mentioned in the paper above referred to indicate that the maximum abundance of the plankton of the North Sea, which was collected on November 12th at a station 22 meters in depth, attains 1240 cc per square meter. And the minimum value, 32 cc per square meter, was found on November 5th from a station 42 meters in depth. These values are also much less than those found in Aomori Bay.

Formerly KOKUBO and KAMADA (1926) made an observation on the plankton collected in Tsugaru Strait, just outside of Aomori Bay, and reported that the 0–200 meter stratum yields 42–73 cc of plankton per square meter. Due to the lack of determination of filtration coefficient their results show only an expedient value. Yet from the comparison of these values to those of Aomori Bay it may be said in all probability that the plankton of Aomori Bay is richer than that in Tsugaru Strait, however large the filtration coefficient might be assumed to be.

Though the descriptions so far made only concern the comparison of volume, the comparison of the number of cells to this volume gives interesting information. On examination of water which was taken on January 16th from the station of present investigation, the number of cells counted 4173 per litre. Therefore, if it were assumed that this water corresponds to the pump collection of Obs. IX (Jan. 19th), the 4173 cells correspond to the volume of 0.01596, viz., 1 cc of plankton (dominated by *Thal'rix nitzschioides*) is equal to 241466 cells. Again, were it assumed that the number of cells in one litre of water which was taken on March 15th (438697 cells) corresponds to the pump collection of March 11th (0.05294 cc), 1 cc of Plankton (dominated by *Ch. debile*) is equal to 83624 cells.

c) The filtration coefficient of the net.

HENSEN (1895) observed the filtration coefficient of the plankton net which was composed of 'Müllergaze' No. 25 (formerly No. 20). According to his results, which he determined by towing the net 10 meters vertically, the filtration coefficient is 1.044, 1.015, 1.591, and 3.578 when the filtration surface is 100 fold, 55 fold, 16 fold, and 4 fold, of the surface of the section area of entrance respectively. Of the two plankton nets which were used in the present investigation the filtration surface of the ordinary net maintained 17.7 fold of the section area of entrance, while in the net of HENSEN's type this ratio was 56 fold. When our nets were towed vertically with a speed of 50 cm per second, the filtration coefficient varied with the depth of collection. This relation can be seen in the following two tables.

TABLE (a), Net of ordinary type.
(Ratio of the section area of entrance to the filtration surface was 1 : 17.7)

Depth of vert. haul (m)	Filt. coef.	No. of hauls.	Probable error.
5-0	3.79	8	0.37
10-0	4.15	2	0.50
15-0	6.62	15	1.23
30-0	7.85	18	1.46

TABLE (b), Net of HENSEN's type.
(Ratio of the section area of entrance to the filtration surface was 1 : 56)

Depth of vert. haul (m)	Filt. coef.	No. of hauls.	Probable error.
15-0	3.12	10	1.64
30-0	6.26	5	1.38

As will be seen in the Table (a) the filtration coefficient of the ordinary net was 7.85 in mean, as it was towed 30 meters vertically.

The probable error in this case was relatively large, showing ±1.46, and in addition the largest individual error among 15 observations reached as high as +5.09. Such a large magnitude and the high variability of the filtration coefficient suggests to us the inadequacy of this net for quantitative purposes. The cause of such an extreme fluctuation of coefficient may readily be seen from the following table.

No. Obs	I	II	III	IV	V	VI	VII
Filt. coeff.	4.10	7.17-7.29	8.76-10.21	5.70	5.68-6.80	4.93	6.65
Vol. of Pl. per cubic m. (c.c.)	78.96	257.25	252.45	211.09	238.00	74.93	28.92

No. Obs.	VIII	IX	X	XI	XII	Mean
Filt. coeff.	10.08	7.74	7.93-8.20	10.90-12.90	8.40	7.81
Vol. of Pl. per cubic m. (c.c.)	41.65	15.96	362.70	533.70	311.30	201.08

Examining the above table one will be aware of a distinct tendency for the magnitude of the coefficient to vary proportionally to the quantity of plankton. Moreover it is obvious from the above table (a) that the magnitude of the coefficient is likewise proportional to the haul distance of the net. Such correlation of the filtration coefficient to the quantity of plankton or to the haul distance signifies nothing but that the more the plankton enters the net the worse the filtration power becomes.

Regarding the net of HENSEN's type, too, the filtration coefficient exceeded our expectation. In the case of the collection of 30 meters the coefficient was found to be 6.26, markedly contrasted with the coefficient of 1.40 in HENSEN's middle net. The probable error was ±1.38, while the largest individual error among five determinations was as large as +3.41. Thus the inadequacy of this net for quantitative purposes was not less than that of the former net.

LOHMANN (1903) investigated the filtration coefficient of HENSEN's net at Syracuse in the Mediterranean Sea. He collected the plankton by hauling the net over 100 meters vertically, and the catch of this collection was compared to that of the pump collection, counting the

plankton number by HENSEN's method. According to his results the filtration coefficient varied with the species of plankton, ranging between 13.0 of Pyrocystis and 19.0 of Vermes. FOLK (1901) made a study of the fresh water plankton, using net and pump concurrently, and found that the pump catch was from 5 to 35 times as much as the net catch. In both of these investigations the filtration coefficient is extremely high due mainly to the great distance of the haul or the high abundance of plankton. Probably the low filtration coefficient (1.30–1.40) of HENSEN's middle net can only be found when the net is hauled ten meters or less, or when hauled through water in which the plankton are much fewer. LOHMANN (1903) made discussion in regard to this point stating that 'Der Coefficient von HENSEN nur berechnet unter der Voraussetzung, dass der Fang keine Verstopfung herbeiführt'.

In the plankton net used in the present investigation the ratios of the section area of entrance to the filtration area were 1 : 17.7 and 1 : 56. Therefore the HENSEN's results which have already been referred to led us to think that the filtration coefficients of our two nets approximated 1.059 and 1.591 respectively. But notwithstanding such expectation the coefficients obtained were so large as aforementioned. As to why these were so, the high abundance of plankton and the exceeding length of haul may be responsible, as has been stated repeatedly. Nevertheless, as was stated by BURCKHARDT (1900), there exists another important factor which interferes with the filtration power of the net. According to him, in a net which has been used over one hundred times the filtration power becomes half as much as that of a new one. In our case, too, the filtration power might have been much decreased inasmuch as the net was slightly old.

In short the result of quantitative study as a result of observations with the present nets may not be accurate because of their large and fluctuating filtration coefficient. To obtain an exact result under conditions like ours the ratio of the section area of entrance to the filtration surface would have to be made greater than 1 : 300. Therefore in neritic areas where the diatom vegetates profusely, quantitative study with the net may be almost impossible unless the distance of vertical hauling is contracted to so short as five meters or less, by using a closing net. Ordinary vertical hauling or so called 'step

collection' (Stufenfang) will not give any exact result when the net is towed 5 meters or more. Of course, such may be the case only with a net which is built of fine meshed 'Müllergaze'. When a larger meshed net is used the result may be quite different, probably showing a much smaller coefficient. But in order to determine the quantity of diatom we are obliged to use gauze No. 25, resulting in that inadequacy of filtration coefficient which renders the quantitative study impossible.

Thus quantitative investigation by using the net is only possible when the closing net is employed as in the case of APSTEIN's (1906) investigation. APSTEIN towed a closing net only five meters in the upper stratum where the diatom crowds densely. Therefore if the upper stratum, in which the diatoms are much concentrated, were divided into thin layers, say of five meters, and provided the closing net were not old, an accurate determination would result. Actually, however, the stratum of diatom reaches from the surface to the 50 meter or at least the 30 meter depth, so that a collection, dividing these layers so thinly as 5 meters, can not be accomplished without much difficulty. So that, like JOHNSTONE and others, we are inclined to conclude that the quantitative study can hardly be accomplished by net except for an estimation of Macroplankton with a coarse meshed net.

Taking this opportunity, we wish to express our deep obligation to Prof. S. HATAI, under whose supervision this work was carried out.

6) SUMMARY.

1) During the period from October to April the mean quantity (from surface to bottom) of the plankton of Aomori Bay varied from 15.96 to 529.40 cc per cubic meter of water. The minimum and maximum throughout all of this season and all depths were 10.00 and 726.60 cc per cubic meter respectively.

2) As far as the present data go the plankton of Aomori Bay seem to show such a distribution that in summer they crowd the upper layer, and with the advance of the season the distribution becomes homogeneous from surface to bottom. During the vernal flourshing, however, distribution becomes irregular, probably because

of the abnormal condtitions due to over population. But for the generalization of the law of distribution a further study may be needed.

3) When the nets whose filtration areas are 17.7 to 56.0 times the entrance area (πr^2) are towed 30 meters vertically, the filtration coefficients are not only very large but also fluctuate so much as to make impossible the use of these nets for quantitative purposes. The present data led us to a general conclusion that the quantitative study may hardly be accomplished by the use of nets, as was stated lately by senior authors.

4) The plankton net of ordinary type used in the present investigation is suitable for qualitative purposes. Its catch ranged from the minimum of 1.4 cc to the maximum of 16.5 cc as it was towed 30 meters vertically.

5) As to whether the phytoplankton exhibits any vertical migration due to the change of intensity of light the present data are not determining. But it can possibly be said that such migration is improbable diurnally, but probable seasonally.

6) During the present investigation the plankton of Aomori Bay was largely dominated by phytoplankton, especially by the following species of diatoms: *Chaetoceras didymum, Ch. Schüttii, Ch. debile, Thalassiothrix Frauenfeldii, Thal'rix nitzschioides, Biddulphia sinensis.* The commonest species found among zooplankton were naupli of Copepods and the following species: *Oithona spp., Paracalanus pavus, Centropages spp., Oikopleura spp.*, etc.

7) The general rule that with the increase of plankton the transparency of the water decreases and the reading of FOREL's scale increases, and vice versa, was distinctly observed.

We are under deep obligation to the SAITÔ Gratitude Foundation (SAITÔ Hôon Kai) for adequate financial support given in carrying the present investigation for which to acknowledge our deep appreciation.

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On the So-called "Cleaning Reflex" in *Carassius auratus* (L)., Iron Fish and Goldfish.[1]

By

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(With Plates XIII–XIV and 4 text-figures.)

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As early as 1870 PAUL BERT, observed in connection with the respiration of fish "un mouvement respiratoire incomplet". FRANÇOIS-FRANK (1906) who investigated this peculiar movement just stated, found from his ink-current experiment that it has a constant periodicity, and called it "Cleaning reflex". Recently YOSHIDA (1920) and MASUGI (1920) published their works on the respiratory center in the fish, both using *Cyprinus carpio* L. By their studies, it has become clear that the cleaning reflex is produced by the automatic excitement in the respiratory center as well as in the respiratory movement, and that the automatic excitement of the cleaning reflex is independent of the respiratory movement itself.

There still remains to be determined as to whether or not the form of the cleaning reflex is specific to any given species or to the varieties. Therefore, I undertook to compare the cleaning reflex in supposedly very closely related forms; *Carassius auratus* (L). or "silver carp", Iron fish and goldfish.

I wish to express my sincere thanks to Dr. SHINKISHI HATAI and assistant professor SEIJI KOKUBO for their kind directions and valuable suggestions given during the course of this study.

I. IRON FISH.

It seems unnecessary to explain about *Carassius auratus* (L). and goldfish, as these two forms are too well known and are cited in most of the works on fishes, but some explanation should be made

[1] Contributions from the Marine Biological Station, Asamushi, Aomori-Ken. No. 68.

on the so-called "Iron fish". How the name of iron fish was originated and how closely this fish is related to *Carassius auratus* (L). is not yet clear, though it is usually stated that the forms similar to that of iron fish can be found among the off-springs of the cross with goldfish. Among the features characteristic to the iron fish we note:

1) All fins, especially the caudal fins, are considerably longer than those in *Carassius auratus* (L).

2) In the iron fish, the nasal capsules are more elongated and are highly developed exhibiting a much more complex form in having many folds with that of *C. auratus* (L).

3) In the iron fish, the pearl organ appears distinctly on its opercula as well as on all fins, but in *C. auratus* (L). it is present but indistinct.

4) In *C. auratus* (L). the females out number the males (100 ♀ : 12.9 ♂ after SASAKI, K. 1926), but in the iron fish the sex ratio is nearly the same.

5) In most typical iron fish, we find that the oral angle distinctly differs from that of *C. auratus* (L).

The iron fish and the American Comét goldfish are believed to resemble each other closely in behavior and possession of the two forked caudal fins of considerable elongations, (HÔZAWA, S. 1927). The iron fish also differs from common goldfish, as the pearl organ in the later appears only in the male, while in the iron fish it appears in both sex, though the pearl organ of the female is not so prominent as that of the male. The goldfish shows differences in many respects when their behaviors are compared.

In natural habitates, the iron fish are always found mingled with *C. auratus* (L)., though the converse is not usually the case. For this reason, I called "co-habitant" when *C. auratus* (L). were mingled with the iron fish or even with the goldfish.

II. MATERIALS.

Both forms of *Carassius auratus* (L). were caught at several places in the Aomori prefecture: Sample I *C. auratus* (L). from the neighboring ponds of the Asamushi Biological Station as well as from the river of Ogawara, Sample II (co-habitant) from the ponds of Tsubaki-

yama, Moura, Nakano, Tsuta and the lake Towada, and Sample III (iron fish) taken from the same ponds of Sample II. Sample IV is "Wakin" which is the most common goldfish in Japan, raised in Tokyo.

The following is the body measurement of fishes used in the present work.

	Body length	Body weight
Sample I...........	8.5 cm.–18.3 cm.	7.2 gr.– 70.1 gr.
Sample II	8.9 cm.–18.8 cm.	8.7 gr.– 73.0 gr.
Sample III	7.8 cm.–22.7 cm.	4.8 gr.–108.0 gr.
Sample IV	8.4 cm.–19.2 cm.	6.8 gr.–121.0 gr.

The fishes smaller than the above measurements were not used. The data on both sexes were taken separately.

III. METHOD OF EXPERIMENT.

The fishes brought into the laboratory from various places were put in the aquarium for at least twenty-four hours before being used. The uniform method of the handling of fish is so important for the present test, that I was obliged to devise some fixed method; that is, the fish was held in a engraved fish-shaped wooden board as shown in Fig. 1. Several wooden plates were prepared to accommodate the

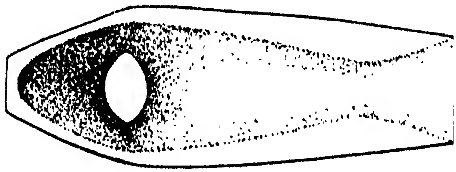

Fig. 1. Showing the fish-shaped engraved wooden board. The fish is kept in this board.

fishes of different sizes. The fish is completely bandaged to the holder with the exception of the head and several scales as is shown in Fig. 2. Special care is given in bandaging the pectoral fins as its motion often changes the respiratory activity of the fish. To the fish thus held, a thread is passed between the operculum and suboperculum and the two ends are tied together so that the knot comes over the center of the operculum as is shown in Fig. 2 and one of the free

ends of the thread is then tied to the lever in order to take the kimographic record of the opercular movements.

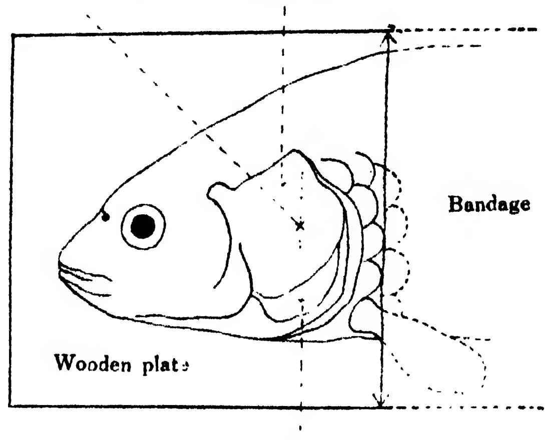

Fig. 2. Showing the bandaging method of the fish.

In the fish thus bandaged, excitement continues usually for the first 5–15 minutes recording the quickened respiratory movements, but apparently normal and uniform rhythms soon follow.

It is needless to say that the mouth and gills should be covered with running water. For this purpose, the bandaged fish was placed into a small box of 350 cc. into which about 800 cc.–850 cc. of water per minute was constantly run through a tube of 1.1 cm. in diameter.

The fish held thus is easily excited and it was often necessary to cover the box with paper or cloth during experimentation.

In the normal resting condition, the cleaning reflex whether it was recorded from the gill slit or from the mouth, appears 1–3 times per minute in all three forms of fishes used. But when fishes were bandaged, the occurrence of the cleaning reflex tends to be more frequent, though in some fishes it occurred less frequent than in the normal resting condition. Seldom, I have noted such cases of fishes in which the cleaning reflex and the respiratory movement occurs alternating.

Since the frequency as well as the mechanisms of the cleaning

reflex may alter under various conditions such as sex, age, holding of fish, exciting, fatigue, temperature of water etc., I made some preliminary tests on all the points just mentioned.

Sex and age: — It became clear that the type of the cleaning reflex is independent of the sex, age and size of the fishes belonging to the same type.

Holding of fish: — It was found that the frequencies as well as the types of the cleaning reflex does not change, if the method of bandaging is uniform. Ordinarily an individual fish shows either one of the types of the cleaning reflex mentioned above, if treated similarly. However, the variations are often produced depending on the different extent of the bandaged area form indicated. As one of the examples, tracings taken from a single iron fish of which the body was bandaged from the sixth scale down to the caudal fins thus allowing free movement of the pectoral fins, showed different forms of the cleaning reflex than is shown by the regular method of bandaging (see Fig. 1.). In Plate XIV in which Fig. 1 was taken by the normal method of bandaging; Fig. 2 the pectoral fins were not bandaged; Fig. 3 the reappearance of the iron fish type after bandaging the pectoral fins.

Fatigue: — The symptom of the fatigue will not appear at least for two and half hours.

Excitement: — In most cases, the excitement produces the faster rhythms and larger amplitudes of the respiratory movements accompanied by equally larger amplitude and greater frequencies (Pl. XIV Fig. 4) of the cleaning reflex, though these alterations just stated do not affect the type of the cleaning reflex.

Water temperatur: — Since the present investigation was undertaken during the period of April-November, the water temperature varied from 11.1°C.–23.0°C.. From a few data taken from the goldfish shows that the type of the cleaning reflex is not modified within the wide range of the temperature of 8.0°C–28.0°C..

IV. OBSERVATIONS ON THE RESPIRATORY MOVEMENT AND THE CLEANING REFLEX.

a) Respiratory movement.

One complete cycle of each respiratory movement may be divided

into three periods, as has been already noted by BAGLIONI (1907), and I shall describe the processes of movements of both gills and opercula based on that of Carassius auratus (L).

The first period: — Mouth and gill slit begin to open almost simultaneously though in reality the mouth begins to open a little earlier than the gill slit.

The second period: — The mouth and gill slit open widely to the limits, but while the mouth opening is performed at once, the opening of the gill slit is performed by two steps, that is, the operculum opens first followed by opening of the opercular membrane. As soon as both the mouth and gill slits reach their maximum, the closing-phase soon follows.

The third period: — Both mouth and gill slit first close half way, followed by the remaining half, but the mouth never closes as completely as the gill slit.

The closing of the gill slit also requires two steps as does its opening, that is, the closing of the operculum followed by the opercular membrane. The movements of the operculum and the opercular membrane are shown in all the tracings. The steps taken in opening and closing of the gill slit are illustrated in Fig. 3. The movements of the mouth and gill slit were recorded simultaneously from a single fish by connecting the threads to two levers. (Pl. XIII, Fig. 1). The correlative movement of these two structures may be clearly seen from the tracings. So far as the form of the respiratory movement is concerned, it is practically the same in the three types of fishes under consideration, as will be seen from several tracings given in Plates XIII and XIV.

b) Cleaning reflex.

The so-called "cleaning reflex" is found in process of movements of the mouth as well as of the gill slit. The forms of the curves recorded these two parts mentioned are different though these occur simultaneously. In the present research I have chiefly studied the type of the cleaning reflex shown by the movement of the gill slit, for the purpose of comparison with the similar observations carried by the other investigators who recorded chiefly that of the gill slit. And similarly I shall describe the cleaning reflex based on *Carassius auratus* (L).

It was found that the mechanism of the cleaning reflex lies on the dissimilar interval of the time taken in movement of the operculum and of the opercular membrane.

As seen from Fig. 3, the cleaning reflex is accomplished in the case of the gill slit by the following steps:

At 1, the operculum begins to close, at 2 its closing is completed, at 3 the opercular membrane begins its closing, thus suddenly producing the curves of the cleaning reflex. At 4, it is completed and then the regular respiratory movement follows.

Comparing the various steps shown by the cleaning reflex in the gill slit with those shown by the mouth, we note the following time relations.

In Fig. 3, 1 and 1′ correspond to the phases where both the operculum and mouth are about closing respectively. At 2, the operculum is closed and at 2′ the mouth is closed almost half way. At 3 the opercular membrane is beginning to close. In this stage of

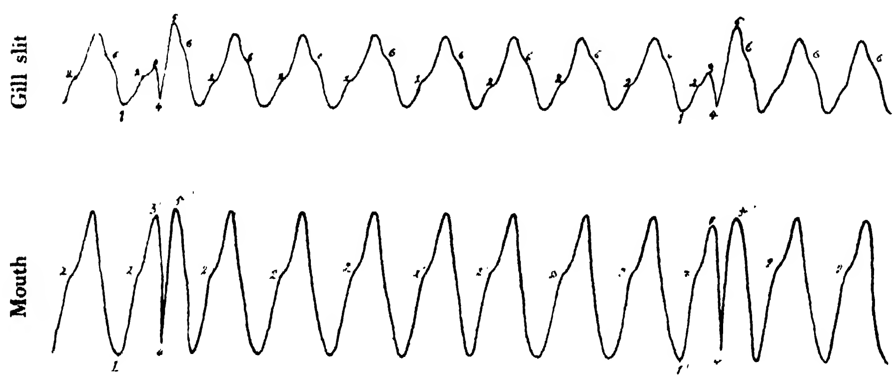

Fig. 3. Though the tracing is shown in Plate 1 Figure 1, the movements of mouth and gill slit were taken separately from single fish is illustrated.

near closing of the opercular membrane, the so-called cleaning reflex arises suddenly in the case of the gill slit, while in the mouth it occurs after 2′, that is, its appearance is little earlier in the former than in the latter. At 4 and 4′ the cleaning reflexes come to the end. The cleaning reflex is followed by longer amplitudes (4–5 and 4′–5′) in the most cases, indicating that the degrees of closing in both the mouth and gill slit are more complete than in the case of usual

respiratory movements. It will be noticed from Fig. 3 that the end of the cleaning reflex in the gill slit (4) and the beginning of the cleaning reflex in the mouth (3′) occur at corresponding periods.

Namely, as FRANÇOIS-FRANK stated already, when the cleaning reflex in the gill slit is about ending, the mouth begins to open and thus these two phenomena are not performed simultaneously as was stated by YOSHIDA and by MASUGI.

V. THE TYPES OF THE CLEANING REFLEX IN THREE KINDS OF FISHES.

The kimographic records of the cleaning reflex were taken from the two groups of *Carassius auratus* (L). non-cohabitant, and co-habitant (see page 534), iron fish and goldfish. It was found from these records, that the type shown in Plate XIII, Fig. 2 occurs predominantly in those groups of *Carassius auratus* (L). which were not mixed with other forms and therefore I have called this type " silver carp type ". Similarly the type of the curves shown in Fig. 3 and 4 occurs more predominantly in the respiration of the iron fish, if we disregard the frequency of " silver carp type ", and thus I named it " iron fish type ", and finaly the type of the curves which is shown in Figs. 5 and 6 occurs more predominantly in the respiration of the goldfish, if we disregard the frequency of " silver carp type ", and thus I named it " goldfish type ".

These three types of the curves occur evidently from the differences in the manner of the closing movements of the operculum and of the percular membrane.

The frequencies of these various types of the curves found in the different groups of fishes are shown in Table I, and the graphical presentation is shown in Fig. 4.

As seen from Table I and Fig. 4, *Carassius auratus* (L). shows, as one should expect, the same type of the cleaning reflex in 82% of fishes examined, and the remainder (18%) shows the types which occur predominantly in the iron fish (13%). The type of the cleaning reflex which is most characteristic to the goldfish is small amounting to 4%.

On the other hand in the " co-habitant " group of the silver carps which were found mingling with the iron fish or with the goldfish,

TABLE I.

	No. of fishes examined	Silver carp type	Iron fish type	Goldfish type
I. *Carassius auratus* (L).	44	36 82%	6 13%	2 4%
II. *Carassius auratus* (L). co-habitant	36	14 39%	11 31%	11 30%
III. Goldfish	66	33 50%	15 22%	18 27%
IV. Iron fish	36	14 39%	15 41%	7 19%

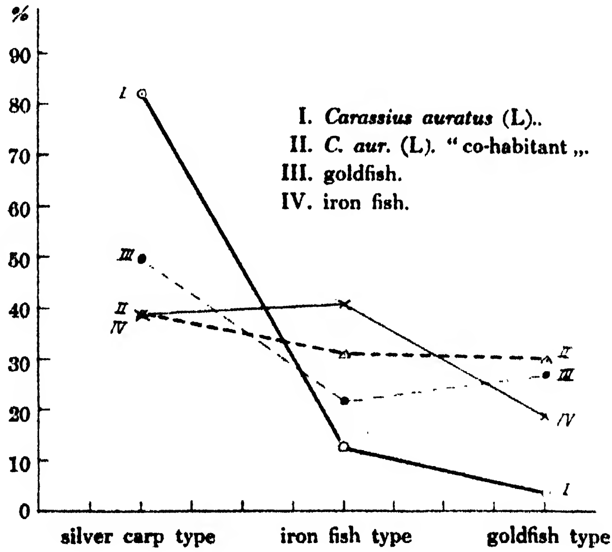

Fig. 4.

and which appear in every respect identical with *C. auratus* (L)., the type of the cleaning reflex shown by the regular *C. auratus* (L). is 39%, and the remainder (61%) shows the iron fish type (31%) and the goldfish type (30%). It is therefore clear that the commonly called silver carps are not always pure *C. auratus* (L)., so far as can be judged from the types of the cleaning reflex.

It is highly interesting to note that half of the goldfish examined

shows the cleaning reflex, the type which is identical with the silver carp and the remainder half gives the other two types, but predominated by one type or what I have called as the goldfish type which amounted to as high as 27%.

In the case of the iron fish, the type characteristic to *C. auratus* (L). is given by 39% of fishes examined. One of the remaining two types which occurs most frequently (41%) in this group of the fish is here called the iron fish type. And the goldfish type occurs only in 19% of them.

As will be better seen from Fig 4, the most predominant type of the cleaning reflex in all four forms of fishes is that of the silver carp type which seems to me to suggest that these four groups of fishes under consideration are closely related to one another, though I am not able to suggest how the three forms were derived from or related to *C. auratus* (L).

In the natural habitates of the iron fish, are always found the apparently pure *C. auratus* (L)., but on the contrary the iron fish is not always found in the natural habitates of *C. auratus* (L). The facts just mentioned seem to support an idea that the iron fish was derived from *C. auratus* (L). under some unknown environmental factors. Even granting that the iron fish was derived from *C. auratus* (L). probably by mutation, but we still encounter the difficulty to explain that how the goldfish is related with either *C. auratus* (L). or with the iron fish. Although we often find in natural habitates of *C. auratus* (L)., the ones with modified pigmentation as is seen in some variety of the goldfish ("Wakin"), as if the goldfish was also derived from *C. auratus* (L)., but all these suppositions would be biologically of no value until we are able to demonstrate the possibility of such derivation directly from one to the other by breeding etc.

If the genetic relations among the four groups become clear, we may better unterstand the real cause of the variations found in connection with the cleaning reflex. It is surfice to say that so far as the present investigations on the types of the cleaning reflex is concerned that these four forms of fishes are very closely related and furthermore practically half of the population of each form exhibits the type of *C. auratus* (L)., while the remaining half exhibits the types characteristic to either to iron fish or to goldfish.

SUMMARY.

1. The so-called cleaning reflex were studied on the four groups of the fishes: *Carassius auratus* (L)., iron fish, goldfish and co-habitant or a group of fish which can not be anatomically differentiated from *Carassius auratus* (L). but was found mingled with either iron fish or with goldfish.

2. It was found that these groups exhibit the type of the cleaning reflex characteristic to each, that is "silver carp type", "iron fish type" and "goldfish type".

3. The greatest percentage of fishes in all four groups, exhibited "silver carp type" and I have discussed its biological significance and suggested that all these four groups may be genetically intimately related to one another.

4. The different types of the cleaning reflex are accomplished from the differences in the movements of the operculum and the opercular membrane.

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EXPLANATION OF PLATE XIII AND XIV.

PLATE I.

Fig. 1. The movements of the mouth and gill slit are shown separately from single *Carassius auratus* (L). Time marking in one second.

Fig. 2–6 show the type of the cleaning reflexes. Fig. 2 "silver carp type", Figs. 3 and 4 "iron fish type", and Figs. 5 and 6 "goldfish type".

PLATE II.

Figs. 1–3 show the cleaning reflex taken from a single iron fish. Normal method of bandaging (Fig. 1); pectoral fins were not bandaged (Fig. 2); the reappearance of iron fish type, after bandaging the pectoral fins (Fig. 3).

Fig. 4. Showing the cleaning reflex of *Carassius auratus* (L). which is not modified by modifying the rate of the respiratory rhythm. Time marking in one second.

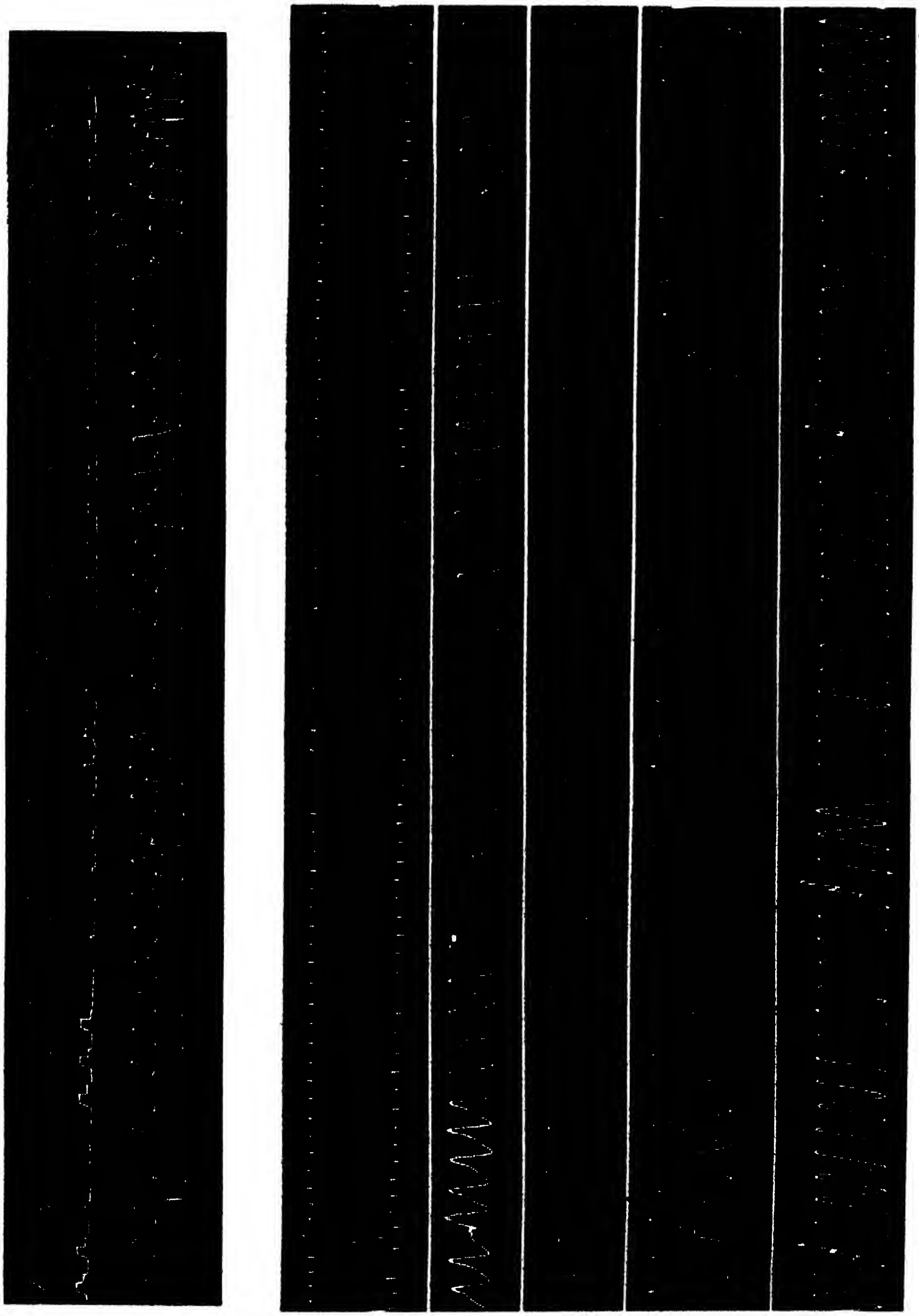


Plate I.

Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6.

S. Kobayashi: On the So-Called "Cleaning Reflex" in *Carassius*.

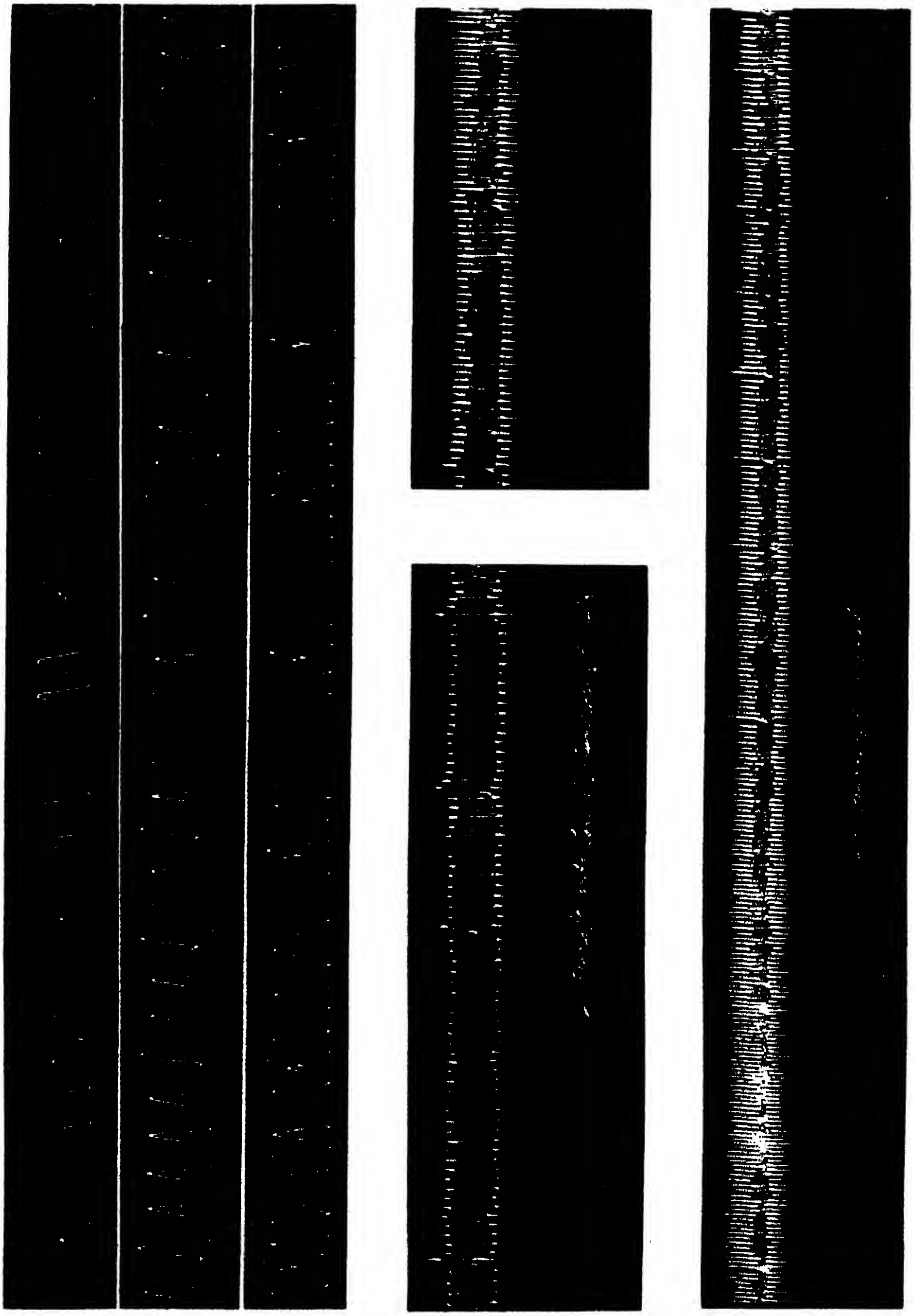


Plate II.

Fig. 1.

Fig. 2.

Fig 3.

Fig. 4.

S. KOBAYASHI: On the So-Called "Cleaning Reflex" in *Carassius*.

Report of the Biological Survey of Mutsu Bay.
21. Hydroiden von Mutsu-Bai, Nord-Japan.[1]

VON

Prof. Dr. E. STECHOW und Dr. TOHRU UCHIDA.

(Mit Tafel XV und mit 12 Textfig.)

(Eingegangen am 17. März 1931.)

Die hier behandelte Ausbeute von der Mutsu-Bai, für die wir Herrn Professor HÔZAWA und verschiedenen anderen Sammlern zu Dank verpflichtet sind, zeichnet sich durch einen bemerkenswerten Reichtum an neuen und interessanten Formen aus. Unter 17 Species enthält sie nicht weniger als 8 neue, ausserdem 2 neue Varietäten, sodass die Hälfte aller behandelten Formen neu ist. Von den neuen Species wurden kurze Diagnosen bereits im Zoologischen Anzeiger (1931) veröffentlicht.

Der Charakter der Hydroidenfauna der Mutsu-Bai ist der der *kühleren* Zone, im Gegensatz zu der bekannten Warmwasserfauna der Sagamibai; hierin dürfte wohl auch der Grund dafür zu suchen sein, dass die vorliegende Ausbeute so wenig Ähnlichkeit mit der Tierwelt der Sagamibai aufweist.

Die Zeichnungen zu dieser Arbeit verdanken wir der geschickten und kundigen Hand des Malers Herrn WALTHER RÖSSLER in München.

ATHECATA.

Fam. Corynidae.

Coryne pusilla GAERTNER 1774.

(Taf. XV Fig. 1).

Coryne pusilla, INABA 1890, Nr. 1, fig. 1–4.
Coryne pusilla, STECHOW 1909, p. 33.
Coryne pusilla, STECHOW 1913 b, p. 49.
Coryne pusilla, STECHOW 1923 a, p. 2, Nr. 1.

Fundorte. Nonaimura; Hadakajima; zwischen Hadakajima und

[1] Contributions from the Marine Biological Station, Asamushi, Aomori-Ken. No. 69.

der Marinen Biologischen Station der Tôhoku Universität, Mutsu-Bai. — Tsuchiya bei Asamushi, Mutsu-Bai. *In voller Fortpflanzung am 1. Juli.* Gesammelt von Professor Hôzawa.— Namiuchi bei Asamushi, Mutsu-Bai. Gesammelt von Professor Hatai und Professor Hôzawa.

Typische Exemplare dieser weitverbreiteten Species.

Coryne uchidai Stechow 1931.

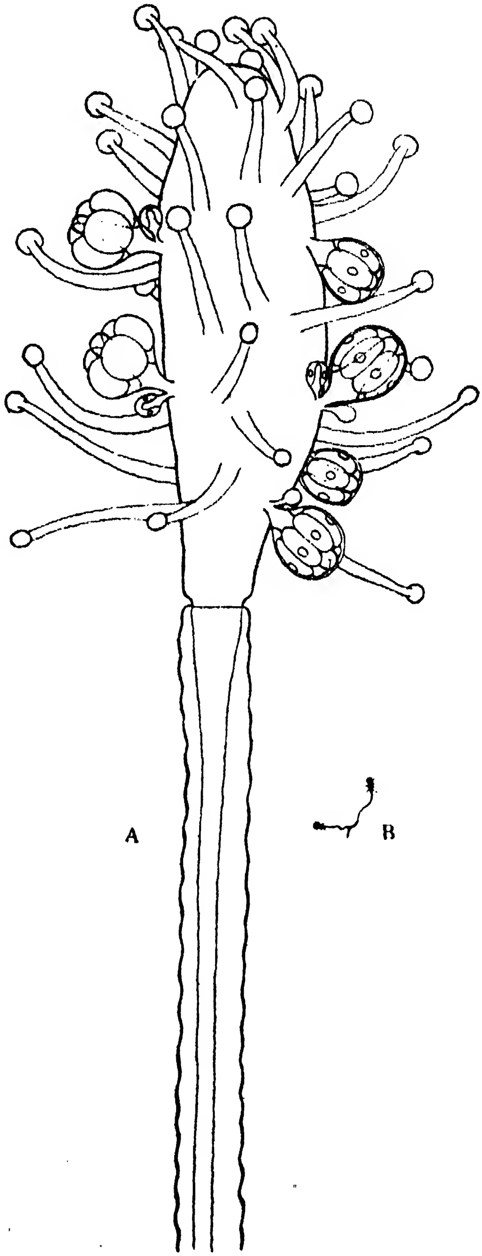
(Textfig. 1).

Fundort. Tsuchiya bei Asamushi, Mutsu-Bai. *In voller Fortpflanzung am 1. Juli.*

Trophosom. (Nur ein kleines 8 mm langes Bruchstück mit 2 Hydranthen vorhanden). Stamm und Zweige runzelig oder wellig, nicht geringelt. Periderm zart, dicht unter dem Hydranthen plötzlich endigend; keine Peridermscheide sich bis auf den Körper des Hydranthen hinauf erstreckend. Hydranthen weit entfernt voneinander stehend, langgestreckt wie bei *Coryne,* spindelförmig, mit 25–30 weit verstreuten, stark geknöpften Tentakeln; die mehr oralen Tentakel dichter stehend und mit stärkerem Nesselknopf, die mehr aboralen dagegen weitläufiger stehend und mit schwächerem Nesselknopf.— Dicke des Stammes 0,160 mm, Dicke des Zweiges an seinem Ursprung 0,130 mm, Länge des Hydranthen 1,6 mm, seine Breite (ohne Tentakel) 0,360–0,480 mm.

Gonosom. Zwischen den unteren und mittleren Tentakeln verstreut 8–12 grössere und viele kleinere Gonophoren an kurzen Stielen, die verschiedenen Grössen durcheinander und meist so, dass die Stiele von 2 oder 3 Gonophoren verschiedenen Alters an der Basis zusammenhängen und dadurch kleine Gruppen entstehen. Gonophoren kugelig, 0,270 mm im Durchmesser, mit starkem Spadix, der das Gonophor bis zum Apex durchsetzt, und mit nur 4–6 grossen Eiern um den Spadix herum. Die Aussenwand des Gonophors ziemlich dünn. Tentakel, Radialkanäle und Ringkanal nicht erkennbar.— Andere, wohl ältere Gonophoren dazwischen sehen aus wie 4–6 aneinander gepresste, sich gegenseitig abflachende Kugeln an einem gemeinsamen Stiel; man hat den Eindruck, dass hier die Aussenwand des Sporosacs geplatzt ist und fehlt, sodass der Spadix mit seinen 4–6 grossen Eiern allein übrig geblieben ist.

Diese Species gehört nach ihren Gonophoren und ihren langgestreckten grossen Hydranthen zu *Coryne;* sie erinnert durch ihr zartes Periderm aber auch etwas an *Sarsia* (*Syncoryne*). Von der scharf geringelten *Coryne pusilla* GAERTNER ist unser Material völlig verschieden. Es hat eine entfernte Ähnlichkeit mit *Coryne* (?) *dubia* RITCHIE von den Kap Verdischen Inseln (RITCHIE 1907 c, p. 491, tab. 23 fig. 1–2), ohne mit derselben indessen völlig übereinzustimmen. — Eine gewisse Ähnlichkeit besteht auch mit *Coryne crassa* FRASER (1914, p. 113, tab. 2 fig. 3); doch hat diese eine stärkere Ringelung der Hydranthenstiele, kürzere Tentakel und weniger Gonophoren.—Ich bin im Übrigen nicht imstande gewesen, unser Material mit irgend einer der bekannten *Coryne*-Arten zu identifizieren. Es ist mir daher eine Freude, diese offenbar neue Art zu Ehren des verdienstvollen Forschers Herrn Dr. TOHRU UCHIDA zu benennen, dem wir eine so viel-



Textfig. 1. *Coryne uchidai* ST. mit Gonophoren.

A vergrössert, B natürliche Grösse.

fache Förderung unserer Kenntnisse der Japanischen Medusenfauna verdanken.

THECATA.

Fam. **Campanulariidae.**

Orthopyxis platycarpa BALE 1914.

(Textfig. 2 und Taf. XV Fig. 2).

Orthopyxis platycarpa, BALE 1914 b, p. 79, tab. 11 fig. 3; tab. 12, fig. 3.

Fundorte. Futagoshima; Urata; Jizomae; Yunoshima; Nonaimura; Bentenjima; Hadakajima; Namiuchi bei Asamushi, Mutsu-Bai. Auf Algen, zwischen *Coryne pusilla* GAERTNER. *In voller Fortpflanzung am 9. Juli.* Gesammelt von Professor HATAI, Professor HÔZAWA, TAKATSUKI, SATÔ und ITÔ.

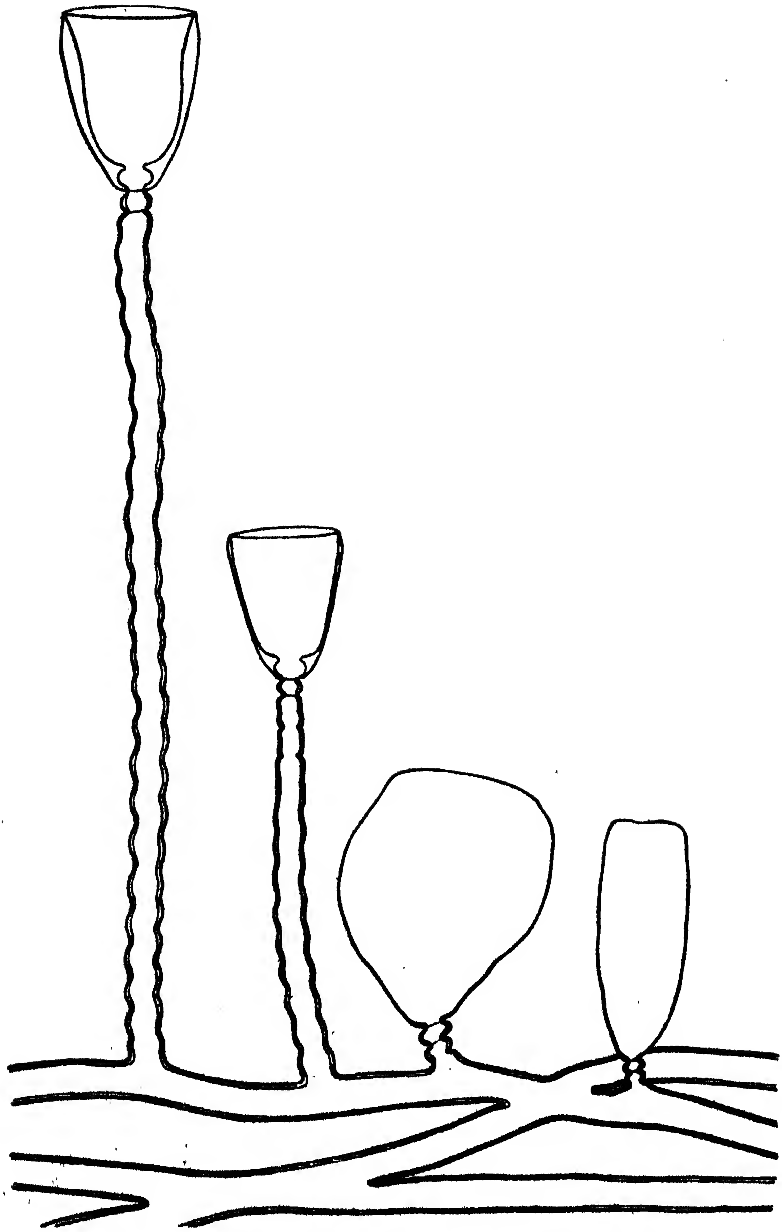
Bisheriger einziger Fundort. Bei Port Phillip, Victoria, Australien (BALE 1914 b).

Für Japan neu.

Trophosom. Eine Anzahl bis 4 mm hoher Einzelhydranthen. Hydrocauli 2-5 mal so lang wie die Theken, wellig, leicht *spiralig* gewunden; unter der Theka ein kugeliger Knopf. Theken glockenförmig, mit dickerer oder dünnerer Wand, je nachdem von welcher Seite man sie betrachtet. Im Thekenboden ein kugeliger Basalraum. Thekenrand glatt, ungezähnt. Länge der Theken 0,320-0,640 mm, Breite der Theken 0,270-0,400 mm.

Gonosom. Gonotheken an kurzem Stiel, breit, *stark zusammengedrückt*, glatt, nur wenig höher als breit, oben quer abgestutzt, mit abgerundeten Ecken, mit 1 oder 2 rückgebildeten Medusen im Innern. Höhe 0,640 mm, Breite 0,400-0,560 mm.

Das vorliegende Material stelle ich zu *Orthopyxis platycarpa*, da es *breite zusammengedrückte* Gonotheken und bei den Hydranthen spiralig geringelte Hydrocauli aufweist, während *Orthopyxis compressa* glatte, hin und wieder quergegliederte Hydrocauli besitzt (s. BALE 1914 b, p. 80; BEHNER 1914, p. 386 ff.). Doch muss bemerkt werden, dass die Gonotheken des Australischen Materials von *Orthopyxis platycarpa* nach BALE mehr als doppelt so hoch und fast doppelt so breit sind als die Gonotheken hier. Ich vermute daher stark, dass es



Textfig. 2. *Orthopyxis platycarpa* BALE. Theken und Gonotheken; die eine Gonothek von vorn, die andere von der Seite gesehen.

sich hier vielleicht doch um eine andere, bisher noch unbekannte Species handelt.

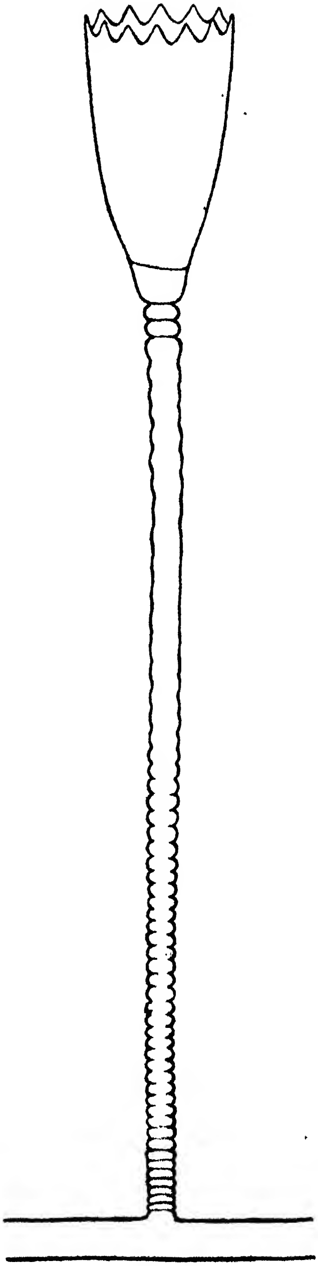
Clytia delicatula (THORNELY 1900).
(Textfig 3).

Clytia sp., INABA 1890, Nr. 13, fig. 34–35.
Obelia delicatula, THORNELY 1900, p. 453, tab. 44 fig. 7.
Campanularia delicatula, JÄDERHOLM 1902 b, p. 3.
Clytia delicatula, STECHOW 1913 b, p. 65, Textfig. 20–21.
Clytia delicatula, STECHOW 1923 a, p. 7, Nr. 63.
Clytia delicatula, STECHOW 1923 c, p. 109.

Fundort. Namiuchi bei Asamushi, Mutsu-Bai. Auf Algen, zwischen *Coryne pusilla* GAERTNER und *Orthopyxis platycarpa* BALE. Gesammelt von Professor HATAI und Professor HÔZAWA.

Nur wenige unverzweigte Hydrocauli bis zu 1 mm Länge. Hydrocauli besonders oben und unten gegliedert, die Glieder breiter als lang. Theken 0,480 mm lang und 0,190 mm breit, sehr zart, mit spitzen Zähnen.

Gonosom fehlt.



Textfig. 3. *Clytia delicatula* (THORNELY).

Fam. **Lafoeidae.**

Lafoea fruticosa (M. SARS 1851).
(Taf. XV Fig. 3).

Lafoea fruticosa, INABA 1890, Nr. 6, fig. 14–16, und 1892 b.

Lafoea fruticosa, VON MARENZELLER 1902, p. 564.
Lafoea fruticosa, LINKO 1911, p. 100, Textfig. 17.
Lafoea fruticosa, STECHOW 1913 b, p. 109, Textfig. 84.
Lafoea fruticosa, KUDELIN 1914, p. 460.
Lafoea fruticosa, JÄDERHOLM 1919, p. 6, tab. 1 fig. 7.
Lafoea fruticosa, STECHOW 1923 a, p. 10, Nr. 98.

Fundorte. Vor Sanbashi, Mutsu-Bai. *Mit vollentwickelten Coppinien mit Eiern im Marsupium am 5. August.* Gesammelt von Professor HÔZAWA und TAKATSUKI.—Vor der Marinen Biologischen Station der Kaiserlichen Tôhoku Universität, Mutsu-Bai.

Fam. **Sertulariidae.**

Symplectoscyphus hozawai STECHOW 1931.

(Textfig. 4).

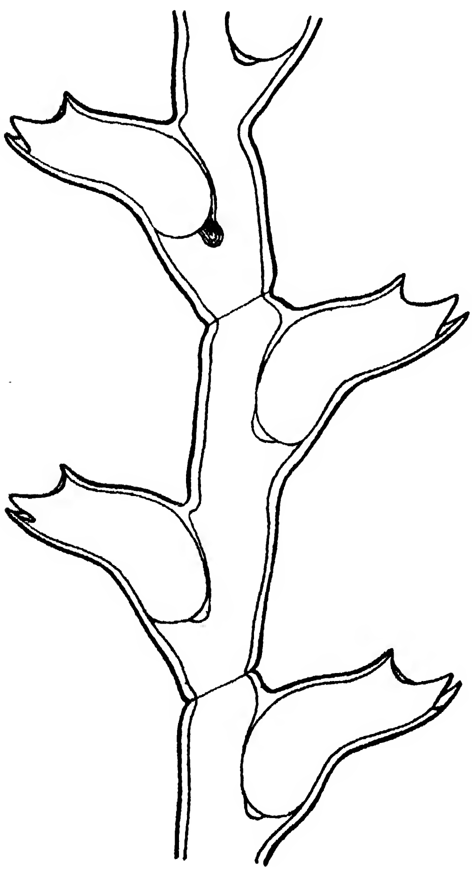
Fundort. Oma-shimote, Mutsu-Bai. Auf der Schnecke *Haliotis gigantea*. Gesammelt von Professor HÔZAWA.

Trophosom. Einige 20–35 mm hohe Stämme mit Hydrorhiza, nicht oder wenig verzweigt, monosiphon; Gliederung schräg, nicht sehr deutlich, unregelmässig, sodass 1, 2 oder 3 Theken auf ein Internodium kommen. Cladien dicht unter einer Theka des Stammes entspringend. Stamm und Cladien mit alternierenden Theken besetzt; die erste Theka des Stammes dicht über der Hydrorhiza, weniger als eine Thekenhöhe über dem Ursprung des Stammes. Zwischen der ersten Theka und der Hydrorhiza 1 oder 2 Ringelungen. Die beiden Thekenreihen nicht einseitig genähert, sondern einander gegenüber in derselben Ebene liegend. Periderm an Stamm und Theken ziemlich dick, dunkelbraun bis gelblich. Entfernung der Theken voneinander im Durchschnitt etwa gleich einer Thekenlänge. *Theken* glatt, ohne Ringelung, am Boden gleich weit wie an der Mündung, in der Mitte am breitesten, ohne Hals, ohne eigentliches Septum im Innern, jedoch anscheinend manchmal mit mehrfachem Thekenboden, zur Hälfte oder mit etwas weniger als der Hälfte angewachsen, dann *stark nach aussen abgebogen*, doch ohne Knick. Abcauline Thekenseite stark concav. Thekenrand mit *drei* grossen Zähnen, die beiden *ab*caulinen grösser als der *ad*cauline. Keine inneren Thekenzähne. Fläche der Thekenmündung infolge der stärker entwickelten abcaulinen Zähne mit der Achse des Stammes oder Cladiums etwa einen Winkel von 60 Grad

bildend. In der inneren unteren Ecke des Thekenbodens eine Peridermverdickung. Weichkörper der Hydranthen nicht erhalten.— Dicke des Stammes etwa 0,160 mm, Länge der Theka an ihrer Aussenseite gemessen 0,320 mm, Breite der Theka an ihrer Basis 0,130 mm, in ihrer Mitte 0,160 mm, an der Mündung 0,130 mm, Länge des dem Cladium angewachsenen Thekenabschnitts 0,160–0,240 mm, Länge des freien Thekenabschnitts 0,190–0,240 mm.

Gonotheken fehlen.

Diese Species erinnert an *Symplectoscyphus delicatulus* (HUTTON 1872) von Neu-Seeland = "*Sertularella capillaris*" ALLMAN 1885 (s. TOTTON 1930, p. 183); doch gibt TOTTON für diese Form an, dass die Theken einseitig genähert sind und erwähnt nichts von einer Ungleichheit der Thekenzähne. Unser Material erinnert ferner an *Symplectoscyphus flexilis* (HARTLAUB 1901) von Calbuco in Chile, an *Symplectoscyphus affinis* (HARTLAUB 1901) von den Falklands-Inseln, sowie an *Symplectoscyphus hesperius* (TORREY 1902) von Californien, der übrigens *nicht* gleich *Symplectoscyphus tricuspidatus* (ALDER) ist, wie an anderer Stelle gezeigt werden wird. Sie erinnert auch an *Symplectoscyphus filiformis* (ALLMAN 1888) von Patagonien, an *Symplectoscyphus modestus* (HARTLAUB 1901) von



Textfig. 4. *Symplectoscyphus hozawai* STECHOW. Stammstück mit Theken.

Feuerland, an *Symplectoscyphus margaritaceus* (ALLMAN 1885) von der Magalhaens-Strasse, an *Symplectoscyphus quadrifidus* (HARTLAUB 1901) aus dem Gebiet zwischen Cap Virgin und den Falklands-Inseln; geringere Ähnlichkeit besteht mit *Symplectoscyphus levinseni* (NUTTING 1904) von den Aleuten. Aber alle diese Formen, die meist vom südlichsten Südamerika stammen, haben eine andere Gestalt der Theken, die bei denselben auf eine längere Strecke mit dem Cladium verwachsen und nicht so stark abgebogen sind. Auch mit *Symplectoscyphus tropicus* (HARTLAUB 1901) ist die vorliegende Form *nicht* identisch.

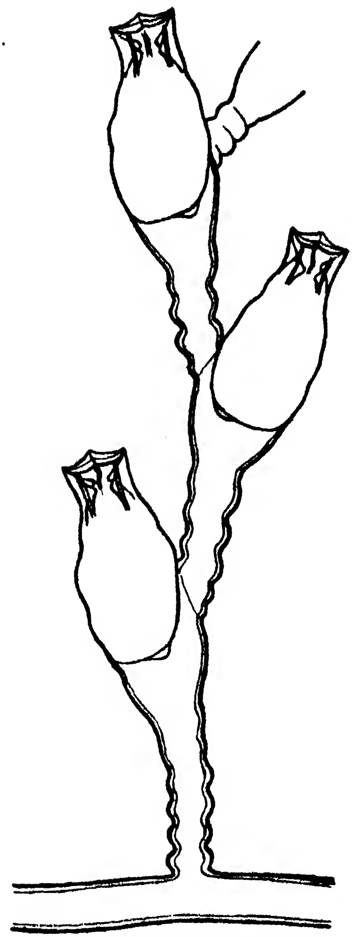
Es ist mir eine Freude, diese bemerkenswerte Species, die anscheinend noch unbeschrieben ist, zu Ehren des Sammlers, Herrn Professor HÔZAWA an der Tôhoku Universität in Sendai, zu benennen, dem wir einen grossen Teil der vorliegenden Sammlung verdanken.

Sertularella quinquelaminata STECHOW 1931.

(Textfig. 5).

Fundort. Hadakajima, Mutsu-Bai. Auf Algen.

Trophosom. Hydrorhiza fadenförmig. *Stamm* bis 5 mm hoch, unverzweigt, die Spitze vielfach in eine Ranke auslaufend, von der erneut einzelne Theken entspringen; neben den Stämmen zahlreiche völlig freie einzelne Theken direkt an der Hydrorhiza, also ganz wie bei *Calamphora*. Stämme mit bis zu 12 Theken, dünn und zart, monosiphon, zickzackförmig, scharf und schräg gegliedert, oberhalb der Gliederung mit etwa 3 scharfen Ringelungen. Periderm nicht besonders dick. Die beiden Thekenreihen nicht immer völlig in einer Ebene liegend, sondern in unregelmässiger Weise einander einseitig etwas genähert. *Theken* alternierend, scharf vom Stamm abgebogen, nur mit etwa einem Drittel angewachsen, dann frei, nicht geringelt, aber oft mit 2–4 undeutlichen Wellen, bauchig, lang, flaschenförmig, mit deutlicher Verengerung unterhalb der Mündung, mit 4 äusseren Zähnen. Operculum aus 4 Klappen. Im Hals 5 grosse deutliche innere Thekenzähne, von diesen 2 kleiner als die anderen. In der inneren unteren Ecke der Theka am Thekenboden ein deutlicher Peridermknoten. Hydranth *mit* abcaulinem Blindsack.— Länge der Theka an ihrer abcaulinen Seite 0,340–0,400 mm, Breite an ihrer Mündung 0,130 mm, im Hals 0,100–0,110 mm, an ihrer breitesten Stelle 0,160–0,190 mm,



Textfig. 5. *Sertularella quinquelaminata* ST. Stammstück mit Theken.

Länge eines Stammgliedes meist 0,500 mm, gegen die Spitze des Stockes zu oft auch nur 0,350–0,400 mm.

Gonosom fehlt.

Diese Species kommt *Sertularella fusiformis* (HINCKS 1861) sehr nahe, von der mir Vergleichsmaterial aus dem Mittelmeer vorliegt (STECHOW 1919 a, p. 84, Textfig. B, und STECHOW 1923 c, p. 180, Textfig. W–X); diese hat aber stets nur *drei* grosse innere Thekenzähne.— Sie ähnelt auch der *Sertularella keiensis* BILLARD 1925 von den Kei-Inseln, Sunda-Archipel (BILLARD 1925 a, p. 147, Textfig. 16); diese hat jedoch *vier* grosse innere Thekenzähne und ihre Theken sind um die Hälfte grösser als die unserer hier vorliegenden Form, die also wohl mit keiner der beiden identisch ist. Sollte sich später vielleicht herausstellen, dass sie mit einer derselben durch Übergänge verbunden ist, so müsste sie den Namen *Sertularella fusiformis var. quinquelaminata*, bezw. *Sertularella keiensis var. quinquelaminata* führen.— Eine gewisse Ähnlichkeit besteht schliesslich noch mit *Sertularella simplex* (HUTTON 1873) von Neu-Seeland (s. BALE 1924, p. 240, Textfig. 7); diese hat jedoch nur 3 kleine innere Thekenzähne.

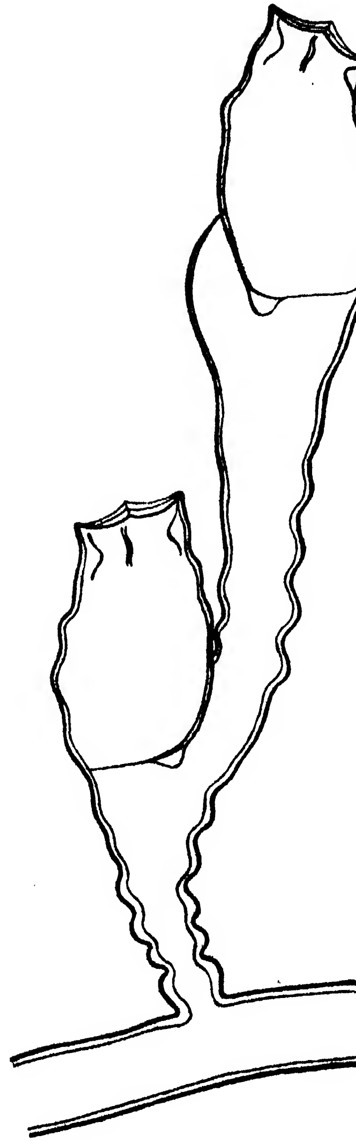
Sertularella mutsuensis STECHOW 1931.

(Textfig. 6).

Fundort. Namiuchi bei Asamushi, Mutsu-Bai. Auf Algen. Gesammelt von Professor HÔZAWA.

Trophosom. (Nur ein kleines Stöckchen mit 2 Theken vorhanden). Stamm nur wenig über 1 mm hoch, unverzweigt, monosiphon, an der Basis mit 4–5 scharfen Ringelungen, ebenso oberhalb der ersten Theka. Periderm unten ziemlich dick, oben dünner werdend. *Theken* alternierend, mit etwa einem Drittel ihrer Länge angewachsen, nicht scharf geringelt, jedoch *mit 2–3* deutlichen Wellen, bauchig, mit gebogener Mittelachse, sich nach oben verjüngend, mit *vier* äusseren Thekenzähnen. Operculum aus 4 Klappen. Im Hals drei innere Thekenzähne. In der inneren unteren Ecke der Theka am Thekenboden ein Peridermknoten. Hydranth *mit* abcaulinem Blindsack.— Länge der Theka an ihrer *ab*caulinen Seite 0,300 mm, an ihrer *ad*caulinen Seite, die etwas länger ist, 0,370–0,400 mm; Breite an ihrer Mündung 0,155 mm, an ihrer breitesten Stelle 0,200 mm.

Gonosom fehlt.



Textfig. 6. *Sertularella mutsuensis* STECHOW.

Diese Species kommt der neuseeländischen *Sertularella robusta* COUGHTREY 1876 nahe (s. BALE 1924, p. 240; JÄDERHOLM 1926, p. 4, Text-fig. 3; TREBILCOCK 1928, p. 16, tab. 6 fig. 3–3 c); sie unterscheidet sich von ihr aber durch kleinere Theken (vgl. die Maasse bei JÄDERHOLM 1926), sowie dadurch, dass ihre Theken nur 2–3 undeutliche und nicht 6 deutliche scharfe Ringelungen haben, wie alle

Autoren für *Sertularella robusta* angeben.— Unser Material hat ferner Ähnlichkeit mit *Sertularella angulosa* BALE 1894 (s. BALE 1894, p. 102, tab. 4 fig. 6, und BILLARD 1925 a, p. 143, Textfig. XIII), sowie mit *Sertularella microgona* VON LENDENFELD 1885 (s. BALE 1888, p. 763, tab. 16 fig. 8, und BILLARD 1925 a, p. 145, Textfig. XIV); diese beiden Arten haben aber erheblich schlankere und längere Theken (vgl. die Maasse bei BILLARD 1925 a), und die Theken zeigen *mehr* und auch schärfere Ringelungen.— Ähnlichkeit besteht auch mit *Sertularella wallacei* STECHOW 1926 von Californien; dieselbe hat aber viel schlankere, schärfer geringelte Theken.— Die weitverbreitete *Sertularella tenella* (ALDER 1856) unterscheidet sich von unserm Material durch *den gänzlichen Mangel innerer Thekenzähne.*

Sertularella miurensis STECHOW 1921 var. **pungens** STECHOW 1931.

(Textfig. 7).

Sertularella sp., INABA 1890, Nr. 9, fig. 22-25; 1892 a.
"*Sertularella indivisa*", STECHOW 1913 b, p. 4, 12 und 134, fig. 106 107.
Sertularella miurensis, STECHOW 1921 c, p. 258.
Sertularella miurensis, STECHOW 1923 a, p. 13, Nr. 134.
Sertularella miurensis, STECHOW 1923 c, p. 175, Textfig. T.

Fundort. Emmusubi-Jizô bei Asamushi, Mutsu-Bai. Auf Algen. *In voller Fortpflanzung am 23. August.* Gesammelt von Professor HÔZAWA.

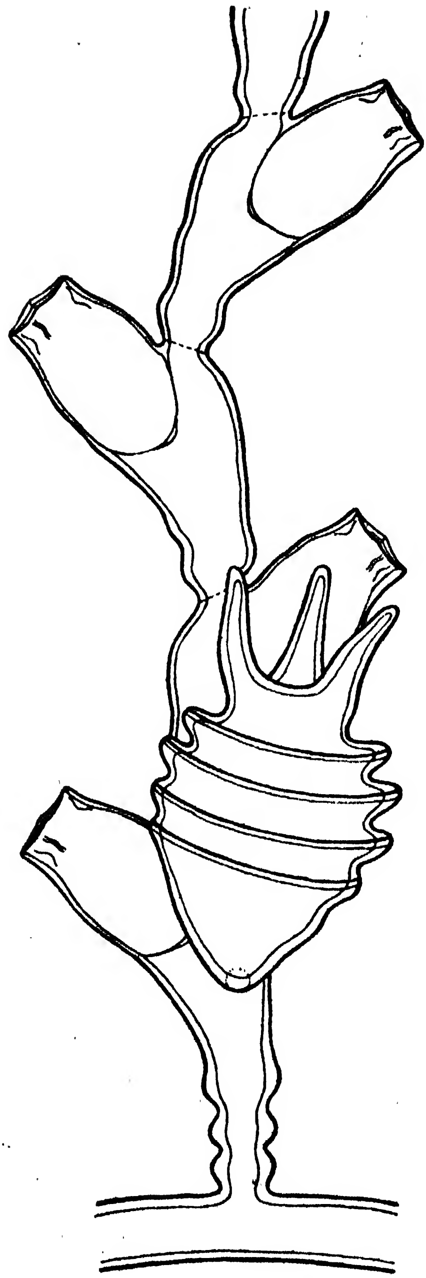
Bisheriger einziger Fundort. Sagamibai (STECHOW 1923 c).

Trophosom. Stamm meist unverzweigt, gelegentlich mit einigen Seitenzweigen, bis zu 14 mm hoch, mit 2–3 starken Ringelungen an der Basis, monosiphon, sehr scharf und regelmässig gegliedert. Periderm am Hydrocaulus und an den Theken dick; an der inneren Ecke des Thekenbodens eine Peridermverdickung. Die beiden Thekenreihen nahezu in einer Ebene liegend; doch springt die Anordnung bisweilen aus der einen Ebene heraus und geht in einer anderen Ebene weiter. *Theken* alternierend, ziemlich nahe beieinander, zu etwas mehr als einem Drittel angewachsen, dann frei und abstehend, fast immer glatt, selten mit schwachen Andeutungen einer Ringelung, gegen die Mündung zu etwas halsartig verengert. Thekenrand mit *vier* kleinen Zähnen. Operculum aus 4 Klappen. Drei *kleine* innere Thekenzähne. Hydranth mit abcaulinem Blindsack.— Länge der *ab*caulinen Thekenseite 0,350mm,

Breite der Theka an ihrer breitesten Stelle 0,250 mm, an der Mündung 0,180 mm.

Gonosom. Gonotheken fast immer am unteren Teil des Stammes entspringend, neben jeder Theka immer nur eine, jedoch mehrere an demselben Stamm, an kurzem ungeringeltem Stiel, ebenfalls mit besonders dickem Periderm, bauchig, oval, mit 4–7 scharfen, spiralig herumlaufenden Ringelungen, ohne stumpfen Mündungsteil, ohne Mündungsrohr, meist mit 3 sehr langen spitzen Dornen am Apex, ohne Stiel und ohne Dornen etwa 0,650–0,800 mm lang und 0,560 mm breit.

Das vorliegende Material ist von den Typusexemplaren der Art durch öfter vorkommende Verzweigung, durch schärfere Gliederung des Stammes, durch *schwächeres* Periderm (besonders an den Theken), durch *kleinere* innere Thekenzähne, sowie durch meist in Dreizahl vorkommende ***lange spitze Dornen an den Gonotheken*** unterschieden. Im Übrigen stimmt es, auch in Bezug auf die Maasse, mit den Typusexemplaren überein, sodass ich glaube, die Form noch als Varietät von *Sert. miurensis* auffassen zu können; sie möge *Sertularella miurensis var.*



Textfig. 7. *Sertularella miurensis var. pungens* St. Theken und Gonothek.

pungens heissen.— Mit *Sertularella spinosa* KIRCHENPAUER 1884, von der mir Vergleichsmaterial vorliegt, hat die vorliegende Art trotz der Ähnlichkeit der Gonotheken *nichts* zu tun, da deren Theken eine ganz andere Gestalt haben.— Sollten spätere Untersuchungen die Notwendigkeit einer völligen Trennung unserer Form hier von der in der Sagamibai vorkommenden *Sertularella miurensis* ergeben, so möge dies Material von der Mutsu-Bai *Sertularella pungens* heissen.

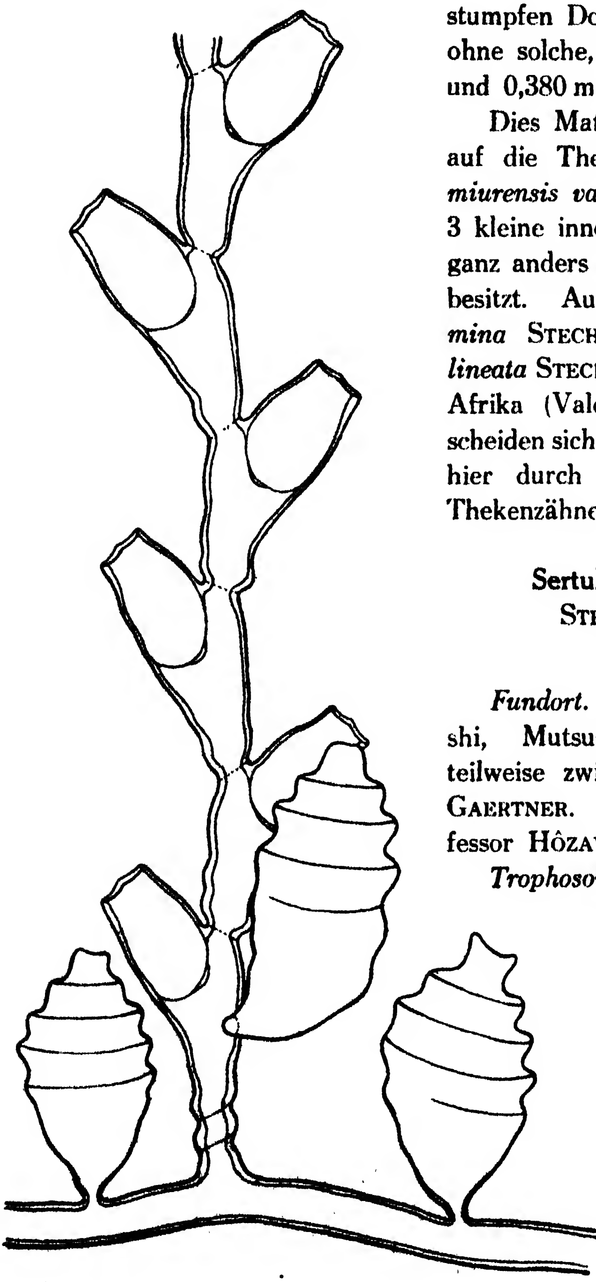
Sertularella obtusa STECHOW 1931.

(Textfig. 8).

Fundort. Emmusubi-Jizô bei Asamushi, Mutsu-Bai. *In voller Fortpflanzung am 23. August.* Auf Algen, zwischen Stöcken von *Sertularella miurensis var. pungens.* Gesammelt von Professor HÔZAWA.

Trophosom. Stamm unverzweigt, bis zu 7 mm hoch, mit 2–3 etwas schiefen Ringelungen an der Basis, monosiphon, scharf und regelmässig gegliedert. Periderm am Hydrocaulus und an den Theken dick, besonders im obersten Drittel der Theken; an der inneren adcaulinen Ecke des Thekenbodens eine Peridermverdickung. Die beiden Thekenreihen meist in einer Ebene liegend; doch kommen nicht selten auch andere Anordnungen vor, z. B. in drei Längsreihen am Stamm, sodass also jede vierte Theka wiederum über der ersten steht, indem die drei Thekenreihen um je 120 Grad voneinander entfernt sind. *Theken* alternierend, ziemlich nahe beieinander, mit etwas mehr als einem Drittel angewachsen, dann frei und abstehend, glatt, gegen die Mündung stark verengert, doch ohne Hals, von Gestalt fast eiförmig. Der Thekenrand an den vorliegenden Exemplaren durchweg beschädigt; doch scheinen vier kleine Zähne und ein Operculum aus 4 Klappen vorhanden zu sein. *Keine* inneren Thekenzähne. Hydranth mit abcaulinem Blindsack.— Länge der abcaulinen Thekenseite 0,300–0,320 mm, Breite der Theka an ihrer breitesten Stelle 0,250–0,260 mm, an der Mündung 0,140–0,160 mm.

Gonosom. Gonotheken am unteren Teil des Stammes oder an der Hydrorhiza entspringend, neben jeder Theka immer nur eine, jedoch mehrere an demselben Stamm, an kurzem ungeringeltem Stiel, mit zartem Periderm, spindelförmig, mit etwa 4 starken Ringelungen, ohne Mündungsrohr, jedoch mit stumpfem Mündungsteil, mit 2 kleinen



Textfig. 8. *Sertularella obtusa* STECHOW. Theken und Gonotheken.

stumpfen Dornen am Apex oder ohne solche, etwa 0,880 mm lang und 0,380 mm breit.

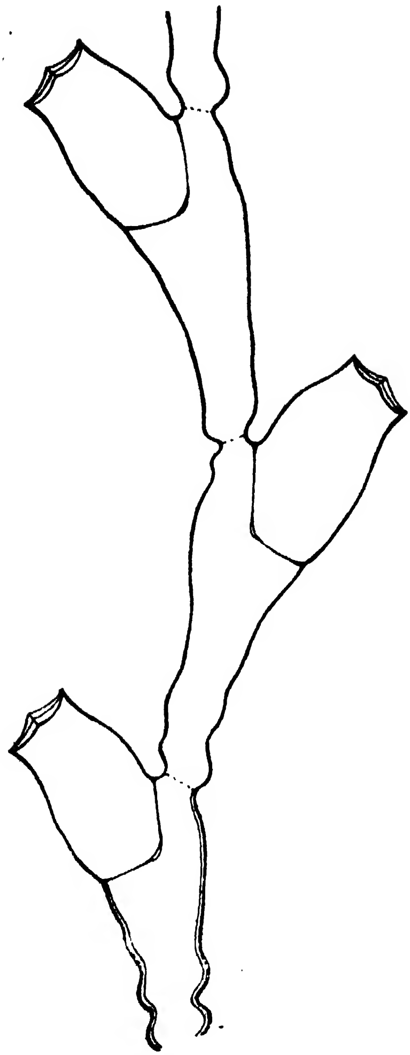
Dies Material ähnelt in Bezug auf die Theken der *Sertularella miurensis var. pungens*, die jedoch 3 kleine innere Thekenzähne und ganz anders gestaltete Gonotheken besitzt. Auch *Sertularella sagamina* STECHOW und *Sertularella lineata* STECHOW, letztere von Süd-Afrika (Valdivia-Material), unterscheiden sich von unserem Material hier durch den Besitz innerer Thekenzähne.

Sertularella levigata STECHOW 1931.

(Textfig. 9).

Fundort. Tsuchiya bei Asamushi, Mutsu-Bai. Auf Algen, teilweise zwischen *Coryne pusilla* GAERTNER. Gesammelt von Professor HÔZAWA.

Trophosom. Stamm nicht verzweigt, bis 12 mm hoch, *monosiphon*, regelmässig und *scharf gegliedert*. Periderm (ausser an der Basis des Stammes) zart. Die beiden Thekenreihen meist in einer Ebene liegend; die Stämme jedoch bisweilen etwas um ihre Längsachse gedreht, die



Textfig. 9. *Sertularella levigata* St. Theken.

Thekenanordnung dann etwas spiralig. *Theken* alternierend, ziemlich weit entfernt voneinander stehend, *mit etwas weniger als der Hälfte ihrer Länge angewachsen*, dann frei, im Ganzen fast gleich weit, in der Mitte nur wenig breiter ohne Hals, ganz glatt und ungeringelt. Thekenrand mit *vier* deutlichen, gleich grossen Zähnen. Operculum aus 4 Klappen. *Keine inneren Thekenzähne.* Hydranth mit abcaulinem Blindsack.—Länge der abcaulinen Thekenseite 0,350 mm, Weite der Theka an der breitesten Stelle 0,225 mm, Mündungsweite 0,200 mm.

Gonosom fehlt.

Diese Species gehört in die Gruppe von *Sertularella polyzonias* (L.) = *S. implexa* (ALLMAN 1888); von ersterer liegt mir Vergleichsmaterial aus Plymouth vor, das jedoch *grössere* Theken und *keine so scharfe* Gliederung der Stämme aufweist; dasselbe ist der Fall bei *Sertularella xantha* STECHOW 1923. Unser Material hier erinnert auch an *Sertularella conica* ALLMAN 1877 und an *Sert. valdiviae* STECHOW 1923; diese beiden besitzen aber Theken mit leichter Ringelung, die auch weiter voneinander entfernt stehen. *Sertularella clausa* (ALLMAN 1888) hat etwas conische Theken, einen ungewöhnlich festen Opercularapparat und ist eine Tiefseeform aus 1100 Metern Tiefe. *Sertularella thecocarpa* JARVIS 1922 hat Hydrocauli, deren Gliederung, wenigstens in ihrem oberen

Teil, bei weitem nicht so scharf ist wie hier. *Sertularella minuscula* BILLARD 1924 aus dem Sunda-Archipel hat viel kleinere Theken und keine so scharfe Gliederung des Stammes. Das vorliegende Material ist jedenfalls mit keiner der genannten Formen identisch.

Sertularella inabai STECHOW 1913.

Diphasia sp., INABA 1890, Nr. 11, fig. 29–31.
Sertularella inabai, STECHOW 1913, p. 141.
Sertularella inabai, STECHOW 1913 b, p. 130, Textfig. 101–103.
Sertularella inabai, JÄDERHOLM 1919, p. 19.
Sertularella inabai, STECHOW 1923 a, p. 14, Nr. 138.

Fundort. Takaisozaki bei Sai, Mutsu-Bai. *In voller Fortpflanzung am 17. August.* Auf Algen, zusammen mit *Plumularia obliqua* (JOHNSTON).

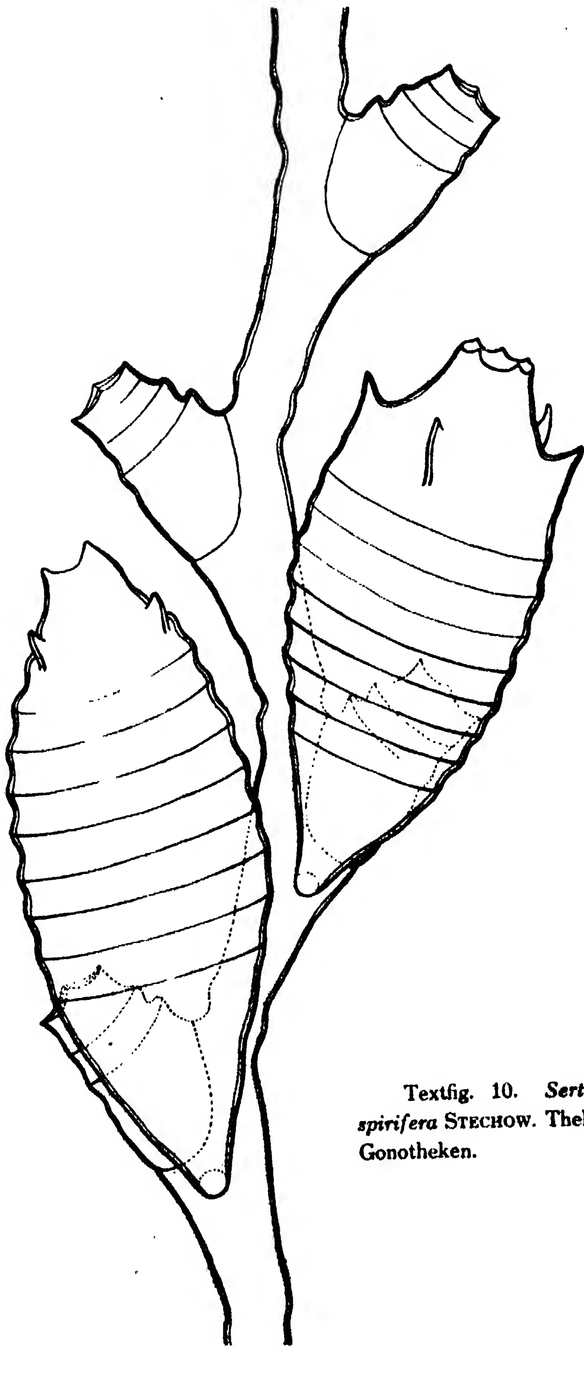
Sertularella spirifera STECHOW 1931.

(Textfig. 10 und Taf. XV Fig. 4).

Fundort. Noheji bei Asamushi, Mutsu-Bai. *In voller Fortpflanzung am 22. August.* Gesammelt von Herrn KOKUBO und Herrn KAMADA.

Trophosom. Stamm dichotom verzweigt, bis 8 cm hoch, ganz monosiphon, regelmässig jedoch nicht sehr scharf gegliedert. Periderm an Stamm und Theken von geringer Dicke. Beide Thekenreihen in einer Ebene liegend. *Theken* alternierend, ziemlich weit entfernt voneinander stehend, *zur Hälfte angewachsen*, dann frei, in der Mitte am breitesten, gegen die Mündung zu sich ein wenig verengernd, doch ohne Hals, in der distalen Hälfte mit 2–3 starken Ringelungen, die an der *ad*caulinen Thekenseite besonders scharf sind; *ab*cauline Thekenseite nur leicht wellig. Thekenrand mit *vier* deutlichen gleich grossen Zähnen. Operculum aus 4 Klappen. *Keine inneren Thekenzähne.* Hydranth *mit* abcaulinem Blindsack.— Länge der *ab*caulinen Thekenseite 0,460 mm, Breite der Theka an ihrer breitesten Stelle 0,290 mm, Mündungsweite 0,225 mm.

Gonosom. Gonotheken (Geschlecht nicht erkennbar) an den unteren Teilen des Stammes dicht unterhalb der Theken entspringend, oft zu mehreren an demselben Stamm, an jeder Theka jedoch nur eine, an kurzem ungeringeltem Stiel, mit stumpfem Mündungsteil, ohne Mündungsrohr, gross, gestreckt, spindelförmig, deutlich geringelt, von etwas



Textfig. 10. *Sertularella spirifera* STECHOW. Theken und Gonotheken.

variierender Gestalt, mit etwa 5 Tuberkeln um die Mündung, ausserdem mit bis zu 5 grossen Dornen in einem Wirtel nicht weit unterhalb der Mündung; die Dornen dieses zweiten Wirtels können an Zahl wie an Grösse fast völlig rückgebildet sein. Länge der Gonotheken 1,360–1,440 mm, Breite 0,560–0,640 mm.

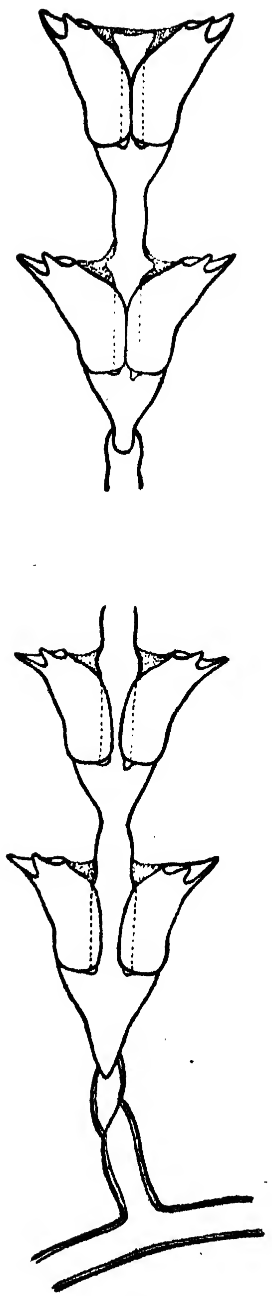
Diese Species erinnert durch ihre geringelten Theken an *Sertularella rugosa* (LINNÉ 1758), an *S. patagonica* (D'ORBIGNY 1839), *S. tenella* (ALDER 1856), *S. microgona* VON LENDENFELD 1885, *S. gayi* (LMX.) *var. annulata* (ALLMAN 1888), *S. angulosa* BALE 1894, *S. tanneri* NUTTING 1904, *S. areyi* NUTTING 1904, *S. annulaventricosa* MULDER & TREBILCOCK 1915, *S. atlantica* STECHOW 1920, *S. striata* STECHOW 1923, *S. wallacei* STECHOW 1926. Hiervon haben jedoch *S. microgona*, *S. angulosa* und *S. wallacei* deutliche innere Thekenzähne, die bei der vorliegenden Species völlig fehlen. Von *S. gayi var. annulata* (ALLMAN 1888) im Besonderen unterscheidet sich unser Material durch völlig monosiphonen Stamm und durch ihre Theken, die mit nicht mehr als der Hälfte ihrer Länge angewachsen sind. Aber auch die anderen genannten Arten unterscheiden sich durch den Grad, wie weit die Theken dem Cladium angewachsen sind, durch die Art der Ringelung usw. von unserem Material hier, das offenbar eine noch unbeschriebene Species darstellt.

Amphisbetia pacifica STECHOW 1931.

(Textfig. 11).

Fundort. Oma-shimote, Mutsu-Bai. Auf Algen. Gesammelt von Professor HÔZAWA, TAKATSUKI und SATÔ.

Trophosom. Hydrorhiza eine Alge umschlingend. *Stamm* unverzweigt, sehr zart, bis 5 mm hoch, mit bis zu 9 Thekenpaaren. Gliederung nicht sehr scharf, unregelmässig, jedes Glied mit 1–3 Thekenpaaren; die Gliederung etwas unterhalb der Mitte zwischen 2 Thekenpaaren liegend. Zwischen der Hydrorhiza und dem ersten Thekenpaar 2 sehr scharfe schräge Glieder. Periderm dünn und zart, etwas stärker nur in der Ecke zwischen Stamm und Thekenmündung, diese Ecke ganz ausfüllend, sodass die Thekenmündung *nicht* frei emporragt. *Die Thekenpaare auffallend weit voneinander entfernt stehend.* Die beiden Theken desselben Paares fast stets in gleicher Höhe, nur selten ein



Textfig. 11. *Amphisbetia pacifica* STECHOW. Stammstück mit Theken.

wenig gegeneinander verschoben, im unteren Teil des Stammes einander nicht berührend, weiter oben mit einem Drittel oder mit der Hälfte ihrer Länge verwachsen, sodass eine Vorder- und eine Rückseite des Stammes unterscheidbar ist; Theken daher nicht völlig in einer Ebene liegend, die beiden Thekenreihen vielmehr einander einseitig etwas, jedoch nur wenig genähert. *Theken* paarweise, zart, schlank, etwa dreimal so lang als breit, fast bis zur Mündung angewachsen, gleichmässig in sich gebogen, ohne Knick. Thekenrand mit 2 grossen Zähnen, davon der kleinere etwas mehr an der Vorderseite des Stammes. Die Fläche der Thekenmündung nach oben gerichtet, sodass von der Spitze des Aussenzahnes bis zum Stamm eine gerade Linie entsteht, senkrecht zur Längsachse des Stammes. An der inneren unteren Ecke des Thekenbodens ein spitzer, nach unten gerichteter Peridermfortsatz. Hydranth *mit* abcaulinem Blindsack.— Dicke des Stammes 0,065–0,080 mm, an den Knoten 0,050 mm, Entfernung von einem Thekenpaar bis zum andern 0,420–0,600 mm, Länge einer einzelnen Theka an ihrer Aussenseite gemessen 0,210–0,260 mm, Mündungsweite der Theka 0,100 mm, Breite eines Thekenpaares zwischen den Spitzen der äussersten Zähne gemessen 0,370 mm.

Gonosom unbekannt.

Die vorliegende Form hat durch die grosse Entfernung zwischen den aufeinanderfolgenden Thekenpaaren und durch ihre grosse Zartheit Ähnlichkeit mit der Australischen *Amphisbetia gracillima* (BALE 1926), die jedoch verzweigt ist und sich auch durch Einzelheiten in der Gestalt der Theken von unserer Species unterscheidet.

— Ähnlichkeit besteht auch mit *Amphisbetia operculata* (L.); diese unterscheidet sich von unserem Material jedoch darin, dass ihre Theken mit dem obersten Drittel ihrer Länge frei sind und dass sich die Theken desselben Paares nicht berühren.

Fam. Plumulariidae.

Plumularia (Monotheca) obliqua (JOHNSTON 1847).

(Taf. XV Fig. 5).

Plumularia obliqua, HINCKS 1868, p. 304, Textfig. 36, tab. 67 fig. 1, 1 a, 1 b.
Plumularia obliqua, BALE 1884, p. 138, tab. 12 fig. 1–3.
Plumularia obliqua, JÄDERHOLM 1919, p. 22, tab. 5 fig. 6.
Monotheca obliqua, STECHOW 1923 a, p. 17, Nr. 186.
Monotheca obliqua, STECHOW 1923 c, p. 224.

Fundort. Takaisozaki bei Sai, Mutsu-Bai. *In voller Fortpflanzung am 17. August.* Auf Algen, zusammen mit *Sertularella inabai* STECHOW.

Plumularia strictocarpa PICTET 1893 var. japonica STECHOW 1931.

(Textfig. 12 und Taf. XV Fig. 6).

Synonymie von *Plumularia strictocarpa* mit ihren sämtlichen Varietäten:

Plumularia strictocarpa, PICTET 1893, p. 55, tab. 3 fig. 47–49.
Plumularia compacta, THORNELY 1900, p. 457, tab. 44 fig. 3.
Plumularia sargassi, VANHÖFFEN 1910, p. 333, Textfig. 46.
Plumularia strictocarpa, BILLARD 1913, p. 34, Textfig. 25.
Plumularia compacta, } BEDOT 1921 a, { p. 26.
Plumularia sargassi, } BEDOT 1921 a, { p. 28.
Plumularia strictocarpa, } BEDOT 1921 a, { p. 29.

Fundort. Sai-Bai, Urata und Jizomae, Mutsu-Bai. *In voller Fortpflanzung am 17. August.* Auf Algen. Gesammelt von Professor HÔZAWA und TAKATSUKI.

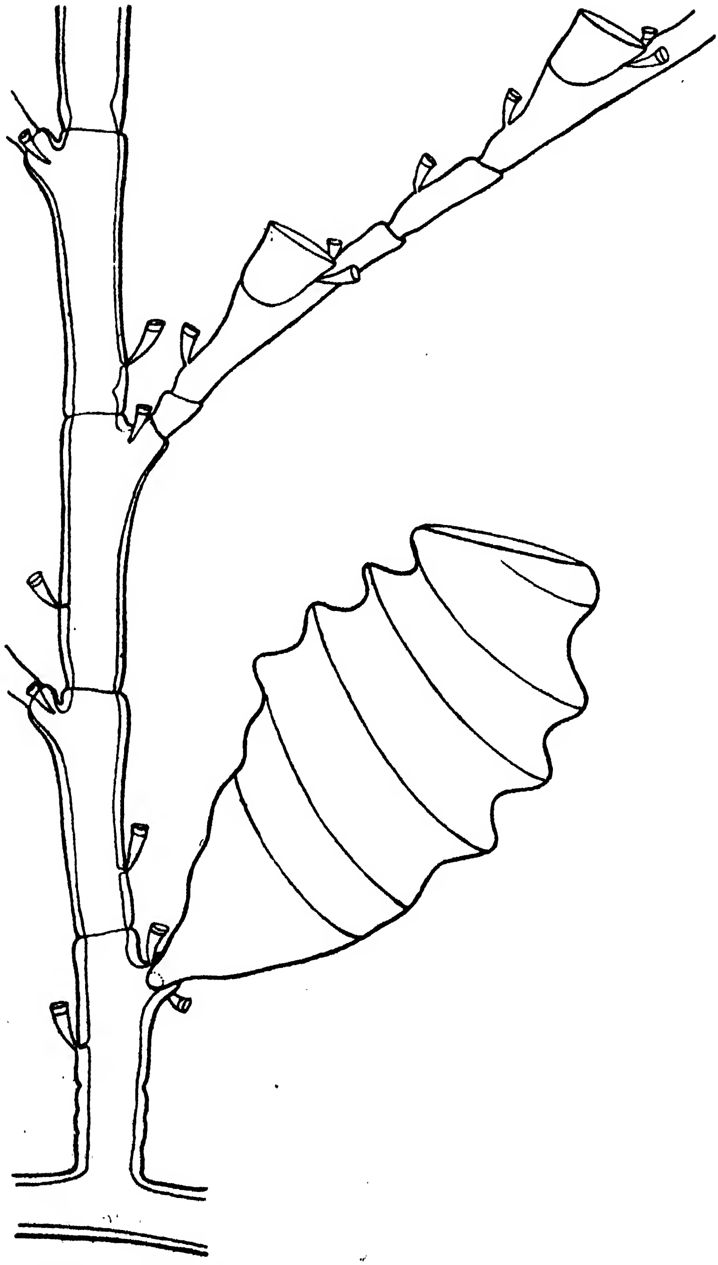
Bisherige Fundorte der Hauptform und ihrer Varietäten. Amboina, Molukken (PICTET 1893), Sunda-Archipel (BILLARD 1913), Neu-Caledonien (THORNELY 1900), südlich der Azoren (VANHÖFFEN 1910).

Trophosom. Stämme klein, zart, monosiphon, unverzweigt, bis 9 mm hoch, regelmässig gegliedert, ohne cauline Theken. Periderm an Stamm und Cladien zart. *Cladien* alternierend, am oberen Ende der

Stammglieder entspringend, ungegabelt, ungeringelt, mit 2-3 Theken, die unteren oft nur mit 1 Theka; die Cladien mit einem kurzen Glied ohne Theka und ohne Nematophoren beginnend, dann abwechselnd längere thekentragende und kürzere thekenlose Glieder; selten einmal 2 thekenlose Zwischenglieder. *Theken* etwas oberhalb der Mitte der Glieder, etwa ebenso tief als weit, becherförmig, ohne Diaphragma, mit ihrer ganzen Rückwand dem Cladium angewachsen; Thekenrand glatt, ungezähnt, fast senkrecht zur Achse des Cladiums stehend. Alle Nematophoren beweglich, zweikammerig trichterförmig; 2 laterale über jeder Theka (ihre Ansatzstelle etwas unterhalb des Thekenrandes); 1 mesiales Nematophor unter jeder Theka; ausserdem 1 einzelnes auf jedem thekenlosen Glied; 1 (selten 2) seitlich an der das Cladium tragenden Stammapophyse, sowie 1 einzelnes weiter unten auf der dem Cladium gegenüberliegenden Seite des Stammgliedes.— Mittlere Länge der Stammglieder 0,770 mm, ihre Dicke 0,090 mm, Länge der thekentragenden Internodien der Cladien 0,320-0,350 mm, Länge der thekenlosen Zwischenglieder 0,160-0,180 mm, Dicke der Cladien 0,045 mm, Weite der Thekenmündung 0,100 mm, Tiefe der Theken 0,095 mm.— Das Trophosom dieser Form erinnert sehr an *Plumularia setacea* (L.).

Gonosom. Gonotheken (anscheinend männliche) einzeln (selten zu zweien) neben den untersten Cladien des Stockes auf der Stammapophyse seitlich entspringend, an ungeringeltem Stiel, etwas krumm und in sich gebogen, mit 4-6 scharfen spiralig herumlaufenden Ringelungen, etwas oberhalb der Mitte am breitesten, gegen die Mündung zu etwas verjüngt, oben breit abgeschnitten, 0,720 mm lang und 0,450 mm breit, Mündungsweite 0,280 mm. 1 Nematophor auf der Stammapophyse unmittelbar neben dem Ursprung des Gonothekenstieles; auf dem unteren Teil der Gonothek keine Nematophoren.

Diese Species kommt *Plumularia strictocarpa*, *Plum. compacta* und *Plum. sargassi* nahe, die man wohl nur als Varietäten einer und derselben Species auffassen kann und von denen die beiden letzteren dann den Namen *Plumularia strictocarpa var. compacta* THORNELY, bezw. *Plumularia strictocarpa var. sargassi* VANHÖFFEN führen müssen.— Die Hauptform *Plum. strictocarpa* (PICTET 1893, BILLARD 1913) unterscheidet sich von unserem Material durch bedeutend grössere Höhe der fertilen Stämme und durch viel längere fast cylindrische Gonotheken mit 10-14 ganz flachen Ringelungen.— Auch *Plum. compacta* ist von unserer



Textfig. 12. *Plumularia strictocarpa var. japonica* ST. mit Gonothek.

Form durch grössere Höhe der fertilen Stämme sowie durch weniger scharf geringelte Gonotheken verschieden, die nach der Abbildung 7–8 Ringelungen haben.— Unser vorliegendes Material von der Mutsu-Bai kommt *Plumularia sargassi* VANHÖFFEN vom Nord-Atlantischen Ozean und *Plumularia compacta* THORNELY von Neu-Caledonien am nächsten. *Plumularia sargassi* hat etwas längere Gonotheken als unsere Form, mit 8–9 Ringelungen, die aber nicht so scharfkantig sind wie hier bei unserem Material. Es ist fraglich, ob dies nur auf Geschlechtsunterschiede zurückgeführt werden kann. Sollten spätere Untersuchungen die Notwendigkeit einer völligen Trennung der Japanischen Form von der *Plumularia strictocarpa*-Gruppe ergeben, so möge dies Material von Nord-Japan *Plumularia japonica* heissen.

Plumularia strictocarpa scheint circumtropisch verbreitet, also eine Warmwasserform zu sein.

Aglaophenia whiteleggei BALE 1888.

(Taf. XV Fig. 7).

Aglaophenia whiteleggei, BALE 1888, p. 794, tab 21 fig. 8.
Aglaophenia sp., INABA 1890, Nr. 28, fig 78–81.
Aglaophenia laxa, STECHOW 1909, p. 93, Textfig. 7, tab. 6 fig. 10–11.
Aglaophenia whiteleggei, STECHOW 1913 b, p. 99, Textfig. 68–70.
Aglaophenia whiteleggei, JÄDERHOLM 1919, p. 24, tab. 6 fig. 1.
Aglaophenia whiteleggei, STECHOW 1923 a, p. 20, Nr. 216.

Fundort. Takaisozaki bei Sai, Mutsu-Bai. Gesammelt von Professor HÔZAWA, TAKATSUKI und SATÔ.

Diese Species nesselt empfindlich.

LITERATUR-VERZEICHNIS.

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ERKLÄRUNG DER TAFEL.

Fig. 1. *Coryne pusilla* GAERTNER.
Fig. 2. *Orthopyxis platycarpa* BALE.
Fig. 3. *Lafoea fruticosa* (M. SARS).
Fig. 4. *Sertularella spirifera* STECHOW.
Fig. 5. *Plumularia (Monotheca) obliqua* (JOHNSTON).
Fig. 6. *Plumularia strictocarpa* PICTET var. *japonica* ST.
Fig. 7. *Aglaophenia whiteleggei* BALE

Die Photographien sind aufgenommen von Dr. TOHRU UCHIDA.

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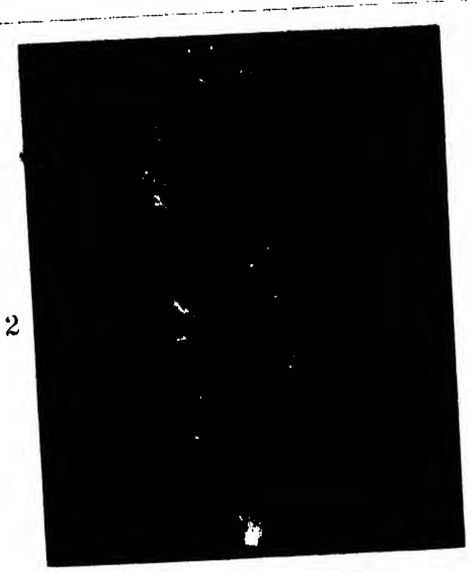

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E. Stechow und T. Uchida: Hydroiden von Mutsu-Bai.

Physiological Studies on *Drosera*.
III. The Effect of Various Acids on the Digestion of Protein by Pepsin.*

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(With 12 Text-figures.)

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I. INTRODUCTION.

In my paper published in 1930 the close resemblance between the proteolytic enzyme in the leaves of *Drosera* and pepsin is reported. Moreover, formic acid is formed in *Drosera*-leaves, so that for the knowledge of these enzymes it is of importance, to study the effect of various acids on the enzymes. But since the results of the studies on pepsin pursued by many authors are different, and, consequently, a standard of comparison is lacking at present, the following investigation was attempted.

The significance of the concentration of acids and the rate of their actions on pepsin have been investigated by many authors. And though the fact was known that pepsin, as is the case with many other enzymes, acts only with in a definite range of acidity, it was shown by SÖRENSEN in 1909 that the digestion is determined by the hydrogen ion concentration and not by the total acidity. MICHAELIS and MENDELSSOHN (1914) made the first attack on investigation of the influence of various acids on the hydrolysis of protein by pepsin, taking into consideration the hydrogen ion concentration. They observed the degree of the digestion of edestin by the pepsin with hydrochloric, nitric, oxalic, and tartaric acids and found that the optimum acidity is at about pH 1.4, whatever acid is used. Further

*Contributions from the Hakkôda Botanical Laboratory, No. 11.

they stated that the pepsin in a form of kation but neither in a form of anion nor undissociated may take part in the action of the digestion of protein.

NORTHROP (1919) demonstrated that "at equal hydrogen ion concentration (at two ranges of pH, pH 1.0 to 1.5 and pH 2.5 to 3.5) the rate of pepsin digestion of gelatin, egg-albumin, blood-albumin, casein, and edestin is the same in the solutions of hydrochloric, nitric, sulfuric, oxalic, citric and phosphoric acids. Acetic acid diminishes the value of digestion of all the proteins except gelatin." He has stated further that the iso-electric point of pepsin is pH 3.0* and the reaction of digestion continues up to about pH 5 (1920), therefore the assumption made by MICHAELIS (1914), that the pepsin attacks the protein only in a state of being positively charged seems unlikely. On the other hand, some authors have studied the behaviour of protein, from the view point of colloid chemistry, i. e., as to its ionisation, hydration and viscosity. BERG and GIES (1907) have noted that digestion depends on the degree of the swelling of the protein. SPRIGGS (1902) and CHRISTIANSEN (1912) stated, that with the progress of digestion the viscosity of the protein solution is diminished. After RINGER (1916) the optimum reaction of digestion is controlled among other factors by the kinds of proteins and acids. He studied especially the digestion of serum acidified with various acids, i. e. sulfuric, hydrochloric, phosphoric, oxalic, lactic, citric and acetic acids. He attempted to explain the phenomenon of digestion by the assumption that the hydration of protein particles in its solution as measured by the viscosity is maximum at the point of acidity at which the digestion reaches optimum, i. e., through the hydration of protein the substrate is hydrolysed most easily by the pepsin. NORTHROP pointed out however that, in opposition to RINGER's idea, the physical properties of the protein solution have little or no effect on the rate of digestion (1919, '20, '23).

I therefore examined the digestion of edestin solutions by pepsin at 39°C with hydrochloric, formic, acetic, propionic, butyric, oxalic, maleïc, malonic, malic, tartaric, and citric acids, and found that the optimum acidity for digestion differs with the kind of acid used, and

* The iso-electric point of pepsin without ashes is pH 2.5, but with a very small quantity of ashes is pH 3.0–3.8 (FENGER, 1928).

the decrease in optimum acidity is parallel, on the whole, to the decrease of the electric dissociation constants of the acids in question.

II. EXPERIMENTS.

A. Experimental Method.

As described in my previous papers (1930), the degree of digestion was determined with the nephelometoric method, making turbid the solution with the addition of 20% sulfosalicylic acid. One gram of edestin was dissolved in a proper quantity of each acid, then this was increased to two liters by adding distilled water, to make the concentration of the digestion solution 0.5‰. The edestin is easily dissolved in the organic acids used, but is difficultly soluble in dilute hydrochloric acid, so that for the latter, the edestin was suspended in 10 c.c. of 25% hydrochloric acid, a small quantity of hot water was added, it was immersed in the water bath at 39°C, water was again added and it was then left for 24 hours to be dissolved in the same bath.

100 c.c. of each of the prepared edestin solutions for each acid were withdrawn and adjusted to proper acidities by means of the potentiometer, by adding either a very small quantity of natrium hydroxyde or one of the acids or distilled water. In every case care was taken not to change the concentration of protein in solutions which had mutually different acidities with a given acid. The enzyme solution used in the experiment was 0.1% pepsin solution dissolved in distilled water (Pepsine Scales MERCK). Therefore I measured again, with the aid of the potentiometer, the hydrogen ion concentration of the mixture of protein and pepsin solutions, and it is given as the pH values of the mixtures in the following tables and figures.

Now, to explain the method of the digestion experiment, an example may be given here. Two ERLENMEYER flasks, of 50 c.c. or less, which contained edestin or 1.5 c.c. of 0.1% pepsin solutions were warmed for 20 or 10 minutes respectively in a water bath at 39±0.05°C. Then 25 c.c. of the edestin solution was taken out, poured into the flask containing the pepsin solution, and the mixture was shaken and left in the same bath. At intervals of 15, 30, 45, and 60 minutes, counting from the time of the mixing of each solution, 5 c.c. of each sample were withdrawn from the mixture solution and placed in a

vessel containing 10 c.c. of cold water, to which was added one c.c. of 20% sulfosalicylic acid to cause turbidity. When the flask was warmed in the water bath, it was bunged with rubber in order to avoid the evaporation of the solution. For the standard solution, a mixture of the same quantity of edestin and boiled pepsin solution as was used in the former experiment, the acidity being kept constant to each corresponding value, was diluted with distilled water up to half the concentration and was then made turbid by the reagent, the height of the liquid column in the nephelometer being kept at 20 m.m. Each standard solution could be used without any change for 60 minutes.

In this way, taking the time of digestion as a criterion, I observed the degree of digestion of edestin solutions acidified with various acids by pepsin and denoted the results in curves, then after a definite time for digestion, which is 60 minutes, again drew a curve to find the optimum hydrogen ion concentration for digestion.

B. The Influence of the Hydrochloric Acid.

The digestion experiments of protein have been mostly carried out with hydrochloric acid. Optimum pH values are gathered from the literature on the subject as is shown in Table I.

TABLE I.

Kind of proteins	Optimum pH	Investigators
acid-albumin	1.6–1.8	SÖRENSEN (1909)
casein	1.8	MICHAELIS and DAVIDSOHN (1910)
,,	1.8-1.9	NORTHROP (1923)
serum	1.8–1.9	RINGER (1916)
,,	1.9–2.0	GYEMANT (1920)
ricin	1.8	GYEMANT (1920)
edestin	1.4	MICHAELIS and MENDELSSOHN (1914)
gelatin	2.4	NORTHROP (1923)
egg-albumin	2.2–2.5	,, (1920, '21).

Table I shows that the optimum reaction is at about pH 1.8–2.0 except in the cases of edestin, gelatin and egg-albumin. After RINGER (1916) the difference depends, in the case of pepsin, upon the kind

of proteins used. LONG and HULL (1917) found a similar fact in trypsin, and NORTHROP (1920, '21 and '23) in pepsin and trypsin.

Experiment 1. Hydrochloric acid.

The results of my experiment are given in Table II.

TABLE II.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
1.24	15.2	20.2	26.0	32.2
1.45	15.7	21.1	28.1	36.1
1.85	16.0	22.4	29.4	38.3
1.97	16.0	22.3	29.3	38.0
2.48	15.8	21.5	27.1	34.9
2.86	13.0	15.2	19.0	32.0
3.12	11.4	12.6	13.3	14.9

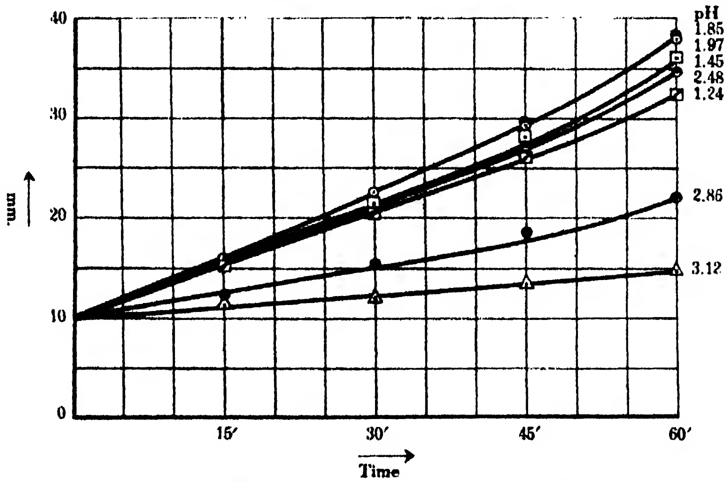

Fig. 1. The experiment acidified with *hydrochloric acid.*

As is shown in Table II and Figs. 1 and 12, in my experiment with hydrochloric acid also, the optimum reaction was found at pH 1.8–1.9, which is different from that of MICHAELIS (1914) with the same sort of protein, and rather agrees with that of most other investigators where different proteins were used, except for gelatin and egg-albumin.

Experiments with the other mineral acids were carried out by some

authors, for example MICHAELIS (1914) with nitric acid; RINGER (1914) with nitric, sulfuric, and phosphoric acids; NORTHROP (1919) with sulfuric, phosphoric acids; and GYEMANT (1920) with sulfuric acid. The results of these experiments agree with each other in the point that with only a few exception the optimum acidity for digestion does not fluctuate much in these mineral acids, whatever may be the sort of protein used. So the question whether the optimum pH differs with the difference of acids or not, seems to lie mainly on the side of the organic acids, which must be further studied below.

C. The Influence of the Organic Acids.

The optimum hydrogen ion concentrations so far known for digestion with various organic acids are: For acetic acid (RINGER, 1916) pH 3.1, for oxalic acid (MICHAELIS, 1914 and RINGER, 1916) 1.8–1.9, for lactic acid (RINGER, 1916) 2.6, for citric acid (RINGER, 1916) 2.5, and tartaric acid (MICHAELIS, 1914) 1.4. After GYEMANT (1920) the optimum digestion of serum acidified with sulfosalicylic acid is at the same hydrogen ion concentration (pH 2.0) as in the case of hydrochloric acid.

In my experiments on the effect of various organic acids, the following were taken: formic, acetic, propionic, butyric, oxalic, maleïc, malonic, malic, tartaric, and citric acids.

Experiment 2. Formic acid.

The result of the experiment with formic acid is given below.

TABLE III.

pH of the digestion mixture	Time of observation. (minutes			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
1.57	10.0	10.3	10.5	10.8
1.90	11.9	13.0	15.0	17.8
2.27	13.0	16.3	19.6	23.3
2.65	13.7	17.2	21.2	28.3
2.99	13.7	17.6	22.8	29.5
3.19	14.0	18.2	23.5	31.2
3.45	13.5	17.0	20.9	25.5
3.65	11.9	13.2	14.2	15.3
3.99	10.8	11.6	12.1	12.3
4.41	10.3	10.6	11.0	11.5

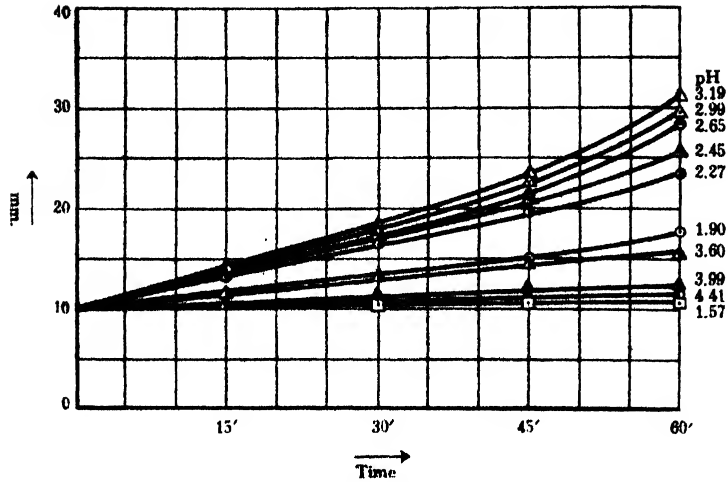

Fig. 2. The experiment acidified with *formic acid.*

As may be seen from Table III and Figs. 2 and 12, the optimum reaction takes place at pH 3.0–3.1. The result closely resembles that of *Drosera*-enzyme which will be reported in the next paper.

Experiment 3. Acetic acid.

The result of the experiment made with acetic acid is given in Table IV and Figs. 3 and 12. The figures show that the optimum acidity for digestion is at about pH 3.0, as was found by RINGER also.

TABLE IV.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
2.29	12.5	15.8	19.8	26.7
2.45	12.8	15.3	20.6	29.5
2.71	13.0	22.4	25.3	35.6
2.86	13.1	18.5	27.6	40.4
2.98	13.4	19.0	29.4	42.2
3.15	13.0	18.0	27.8	40.5
3.29	12.7	15.0	18.3	23.4
3.43	11.4	13.2	14.0	16.2
3.60	10.5	11.5	12.2	13.0

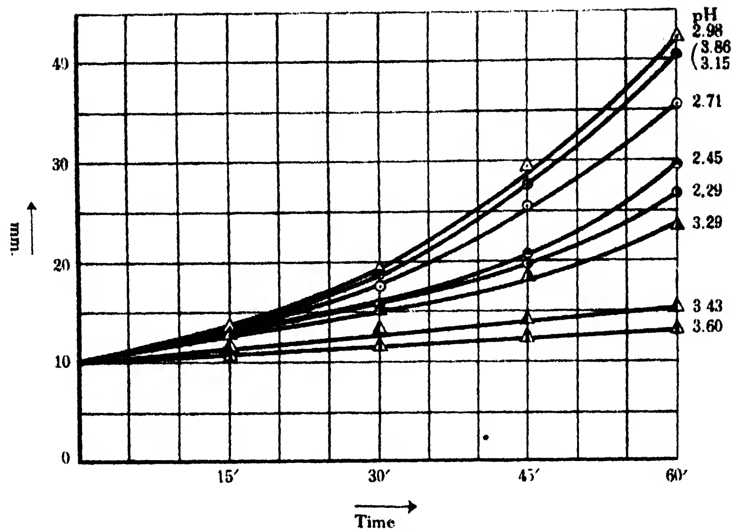

Fig. 3. The experiment acidified with *acetic acid.*

Experiment. 4. Propionic acid.

When propionic acid is used the optimum acidity lies at pH 2.9. (See Table V, and Figs. 4 and 12.)

TABLE V.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
2.29	10.3	10.5	11.3	12.5
2.43	11.9	14.6	18.4	23.8
2.61	12.0	16.0	22.6	31.4
2.75	13.3	17.0	23.3	32.5
2.90	13.5	16.8	23.2	32.7
3.06	10.8	11.2	12.9	15.2

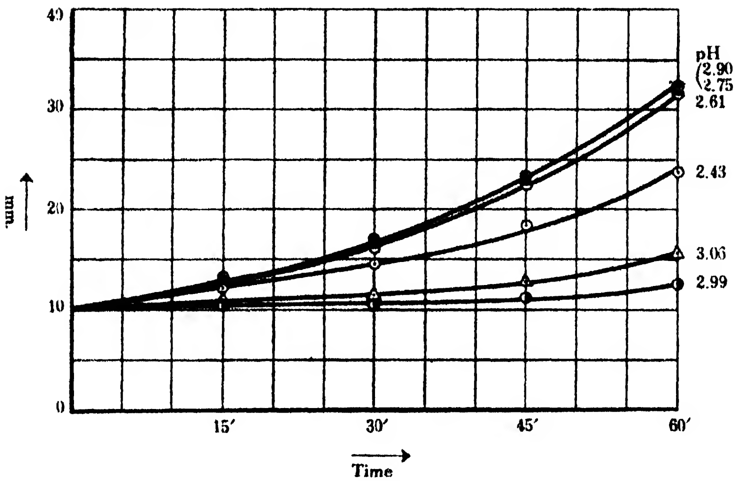

Fig. 4. The experiment acidified with *propionic acid.*

Experiment 5. Butyric acid.

With butyric acid the digestion proceed in that may be seen from Table VI and Figs. 5 and 12. The optimum reaction takes place at pH 2.8–2.9.

Table VI.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
2.11	10.5	10.9	11.5	12.0
2.35	12.3	13.8	17.3	23.0
2.55	12.9	15.3	19.4	25.3
2.70	13.2	16.0	21.0	27.7
2.86	13.2	16.2	20.6	28.0
3.02	11.9	14.2	16.5	20.5
3.12	11.8	13.1	15.0	16.6
3.30	11.0	11.4	12.0	12.5

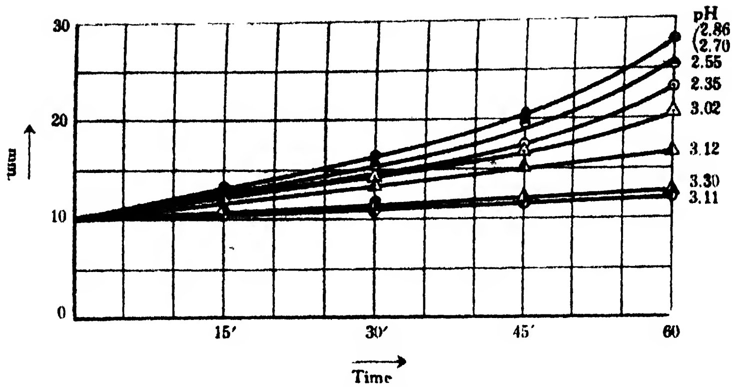

Fig. 5. The experiment acidified with *butyric acid.*

Experiment 6. Oxalic acid.

In the case of oxalic acid, the optimum pH is at 1.9, which coincides with the results obtained by MICHAELIS and RINGER. (See Table VII and Figs. 6 and 12).

TABLE VII.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
1.53	14.1	19.3	24.8	35.0
1.67	14.5	18.7	25.4	35.8
1.85	14.8	20.1	26.7	37.2
2.10	14.9	20.2	25.8	36.5
2.54	13.7	18.2	24.1	33.5
2.88	13.0	15.7	18.9	24.9
3.27	11.7	13.3	15.0	16.8

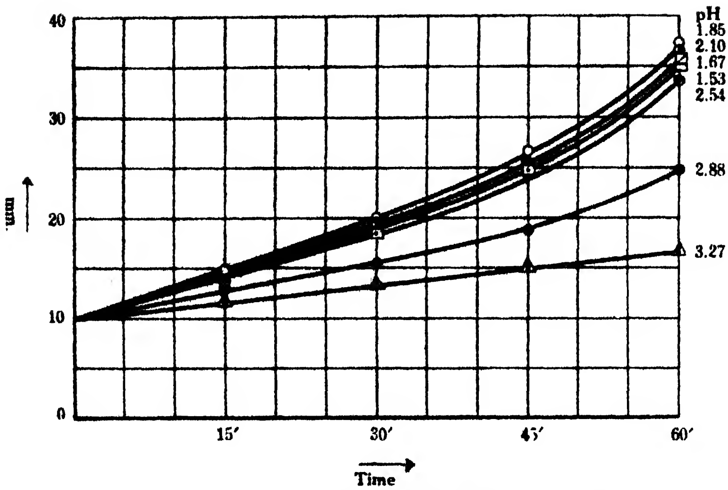

Fig. 6. The experiment acidified with *oxalic acid.*

Experiment 7. Malic acid.

With malic acid the optimum reation takes place at about pH 2.6, as is shown in Table VIII and Figs. 7 and 12.

TABLE VIII.

pH of the digestion mixture	Time of observation. (minutes)			
	15'	30'	45'	60'
	mm.	mm.	mm.	mm.
1.90	12.5	15.0	18.4	25.1
2.30	14.0	17.5	23.0	30.7
2.52	14.5	19.0	25.1	34.4
2.65	13.9	18.8	24.8	34.0
2.90	13.5	17.9	24.0	33.8
3.30	12.4	14.8	16.3	19.5
3.55	11.2	12.5	13.6	15.0

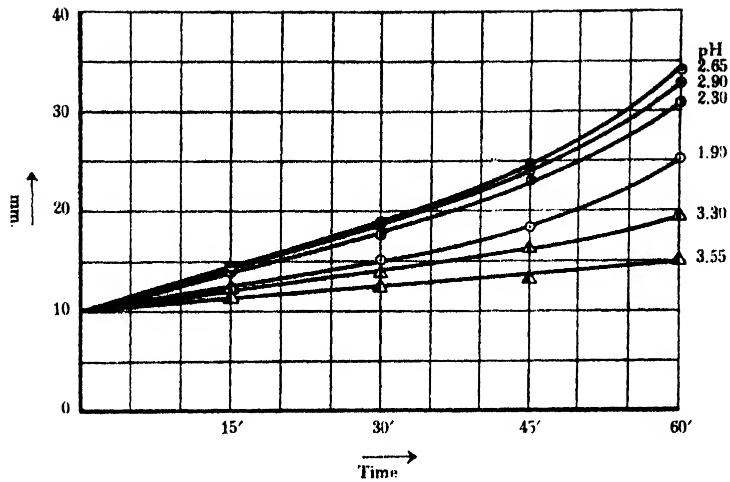

Fig. 7. The experiment acidified with *malic acid.*

Experiment 8. Malonic acid.

When malonic acid is used, the optimum acidity for digestion is about pH 2.6. (See Table IX and Figs. 8 and 12).

TABLE IX.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
1.80	13.2	16.2	20.3	25.4
2.12	14.7	16.4	24.6	31.4
2.45	15.3	17.9	27.9	37.0
2.71	15.2	20.4	29.2	38.9
2.99	15.0	18.7	26.3	35.3
3.29	12.0	14.7	17.4	22.5
3.58	10.5	11.8	13.2	14.6

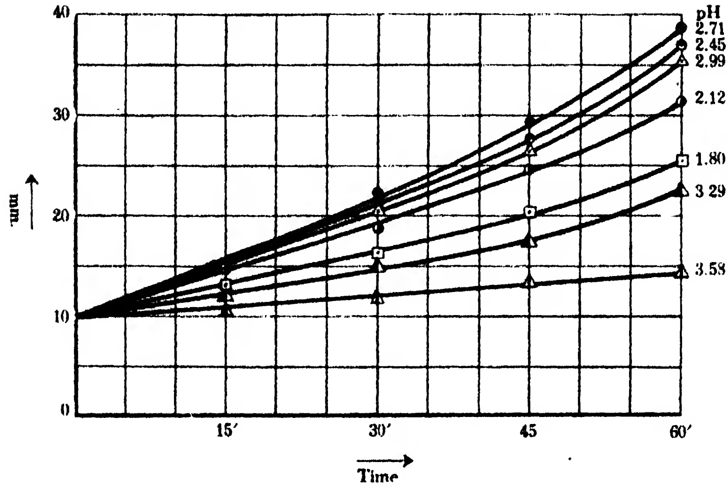

Fig. 8. The experiment acidified with *malonic acid.*

Experiment 9. Maleïc acid.

The optimum pH for digestion in the case of maleïc acid is at 1.8–1.9 as in the cases of hydrochloric and oxalic acids. (See Table X and Figs. 9 and 12).

TABLE X.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
1.15	13.0	15.9	18.3	22.9
1.45	13.4	16.8	21.2	26.7
1.85	13.8	17.1	22.0	27.2
2.29	13.5	16.6	19.5	25.0
2.50	13.3	16.3	18.9	23.2
2.99	11.8	13.7	15.0	17.9

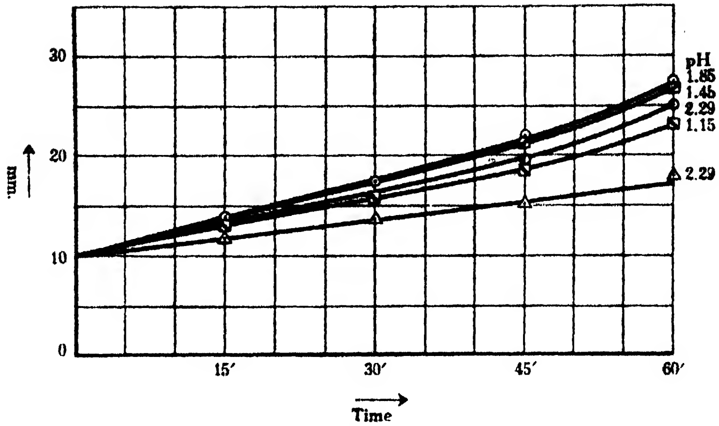

Fig. 9. The experiment acidified with *maleïc acid.*

Experiment 10. Tartaric acid.

By using tartaric acid the optimum reaction takes place at pH 2.5, while MICHAELIS has found it to be at pH 1.4. (See Table XI and Figs. 10 and 12).

TABLE XI.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
1.48	13.2	16.1	21.0	27.4
1.62	13.5	18.7	25.5	33.5
2.04	14.0	19.8	28.1	39.5
2.36	15.3	22.5	33.1	47.5
2.59	15.1	22.2	32.8	47.5
2.92	14.2	20.3	29.8	42.6
3.16	12.8	15.2	18.2	23.6

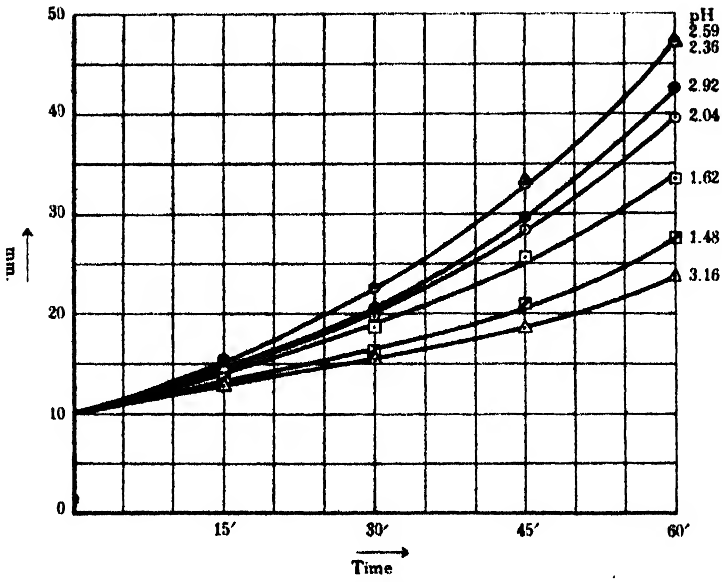

Fig. 10. The experiment acidified with *tartaric acid.*

Experiment 11. Citric acid.

In the case of citric acid the optimum reaction takes place at about pH 2.6, as may be seen from Table XII and Figs. 11 and 12.

Table XII.

pH of the digestion mixture	Time of observation. (minutes)			
	15′	30′	45′	60′
	mm.	mm.	mm.	mm.
2.06	12.4	15.0	20.2	25.3
2.28	13.2	18.8	23.8	31.8
2.34	13.8	18.5	25.5	36.9
2.53	13.9	20.3	28.7	39.5
2.67	14.1	19.9	29.0	40.8
2.84	13.0	17.3	23.1	29.7
3.15	12.5	14.2	17.0	22.8

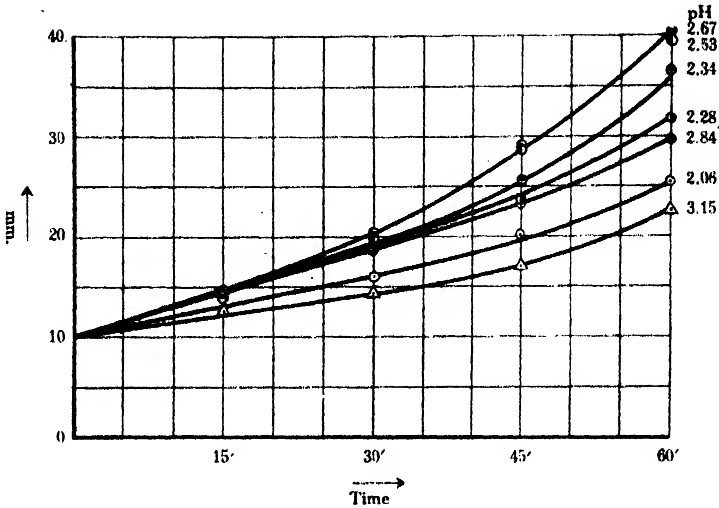

Fig. 11. The experiment acidified with *citric acid*.

From these results we can understand, that when the solution prepared for digestion is acidified with oxalic and maleïc acids a similar acidity to that of hydrochloric acid is found to be optimum, while with other organic acids, so far as the experiment goes, it is different from the former cases. In other words it is demonstrated by this study that the pH values 1.8–1.9 for the optimum reaction is not characteristic for only some mineral acids. In general the results above given agree with RINGER's on the point, that the optimum acidity for digestion undergoes variations with the use of different acids. RINGER explained this phenomenon by the hydration of protein. According to LLOYD's experiment (1920) on gelatin, the degree of its swelling by taking in water is minimum at the iso-electric point, and increases remarkably on both sides of this point in this way, namely that the maximum of swelling on the acidic side is at pH 2.7 while that of the basic side is at pH 12.0. LOEB (1921, '24) demonstrated that the maxima of the swelling, viscosity and osmotic pressure of gelatin solution substantially exist in a similar optimum acidity, namely for the swelling and viscosity the optimum pH is at 2.7–2.8, while for the osmotic pressure it is slightly different from this value. NORTHROP (1923) reported that the optimum acidity for gelatin digestion acidified with hydrochloric acid is at about pH 2.4. These results

may show, that the optimum acidity for gelatin digestion by pepsin should be similar to that for its swelling and viscosity. On the other hand a variation of the hydrogen ion concentration does not have a similar influence on the viscosity of solutions of crystalline egg-albumin and simple amino-acids, such as glycocoll and alanine (LOEB, 1921, '24). With sulfosalicylic acid, which depresses the swelling of protein, has given the digestion experiment the same acidity for optimum as that of hydrochloric acid (GYEMANT, 1920). Further from LLOYD's (1920) and NORTHROP's (1923) experiments, it is evident that the maximum acidity for the swelling of gelatin on the basic side does not coincide with the greatest reaction of digestion by trypsin. So it is very probable, that the greatest reaction of digestion may not take place in parallel with that of the swelling, hydration or viscosity of any protein.

The difference of the optimum acidity in various organic acids may be explained on the assumption that the acidification of the solution of protein with any acid may result in the formation of protein-acid compounds the properties of which are different for different acids, and, as the optimum acidity for digestion varies with the sort of proteins, the protein-acid compounds should be decomposed by pepsin at different optimum acidities. Deducing, from the fact that the optimum acidity for digestion is consistent with the maximum of the combination of protein with pepsin (NORTHROP, 1923) and from the fact that the optimum hydrogen ion concentration for digestion may be different for different acids (RINGER, OKAHARA), may lead us to the idea that the degree of the combination of protein with pepsin is different for different acids.

D. The Relation between the Optimum Acidity for Digestion and the Electric Dissociation Constant.

Recently the affinity between enzyme and substrate has been discussed. This problem was especially emphasized by EULER and JOSEPHSON (1924, '26) with many interesting experiments on saccharase. They stated that enzyme reactions occur through the intermediate stage of enzyme-substrate compounds, the equilibia of which are ruled by the law of mass action. They measured the affinity constants of

these compounds and compared the affinity between various sugars and the enzyme.

Using pepsin I have found that the optimum acidity for digestion differs with different acids and the difference is dependent upon the electric dissociation constant of the the acid used. As, however, dibasic or tribasic acids, for example sulfuric or phosphoric acids, act respec-

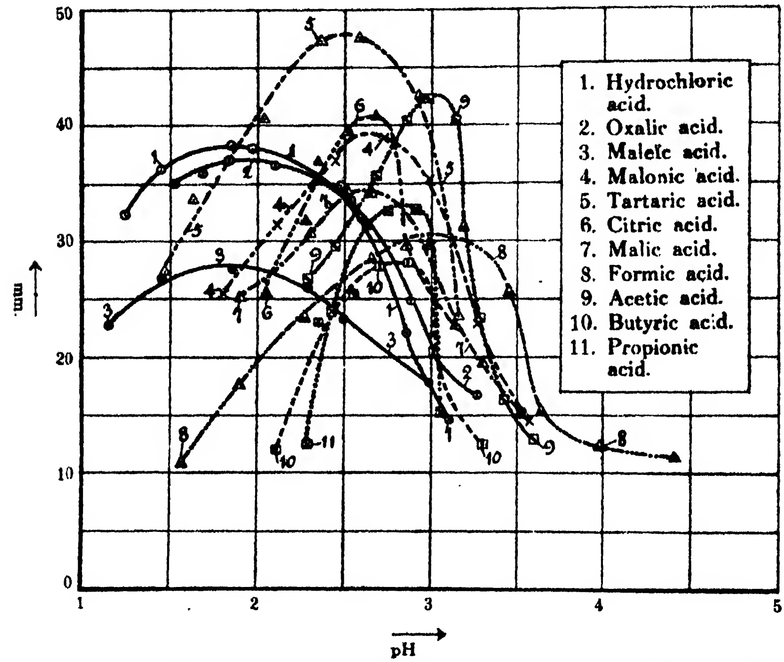

Fig. 12. The relation between the hydrogen ion concentrations of digestion liquids acidified with various acids and the degrees of digestion by pepsin after 60 minutes.

tively in two or three steps at the ionisation, they have two or three dissociation constants. The value for the first step of ionisation is in general greater than for any others. The second or third steps may not be recognised, if the dilution is not so great. Therefore, the value for the first step of ionisation may be taken as the representative of the acid concerned.

The relationship between the optimum acidity for protein digestion and the electric dissociation constants of the acids used is shown in the following table.

TABLE XIII.

No.	Sorts of acids.	Sorts of proteins.	Optimum pH for digestion.	Investigators who observed digestion.	Electric dissociation constants at 25°C.
1	hydrochloric acid	serum	1.8–1.9	RINGER (1916)	—
	,,	,,	1.9–2.0	GYEMANT (1920)	
	,,	edestin	1.9	OKAHARA	
2	nitric acid	,,	1.7	MICHAELIS and MENDELSSOHN (1914)	—
3	sulfosalicylic acid*	serum	2.0	GYEMANT (1920)	—
4	sulfuric acid	,,	1.6–1.7	RINGER (1916)	4.5×10^{-1}
	,,	,,	1.8	GYEMANT (1920)	
5	phosphoric acid	,,	1.9	RINGER (1916)	1.1×10^{-1}
6	oxalic acid	serum	1.9	RINGER (1916)	3.8×10^{-2}
	,,	edestin	1.9	OKAHARA	
7	maleïc acid	,,	1.8–1.9	,,	1.2×10^{-2}
8	malonic acid	edestin	2.6	OKAHARA	1.6×10^{-3}
9	r-tartaric acid	edestin	2.5	OKAHARA	9.7×10^{-4}
10	citric acid	,,	2.6	,,	8.2×10^{-4}
	,,	serum	2.5	RINGER (1916)	
11	malic acid	edestin	2.6	OKAHARA	4.0×10^{-4}
12	lactic acid	serum	2.6–2.7	RINGER (1916)	1.4×10^{-4}
13	formic acid	edestin	3.0–3.1	OKAHARA	2.1×10^{-4}
14	acetic acid	edestin	3.0	OKAHARA	1.8×10^{-5}
	,,	serum	3.1	RINGER (1916)	
15	butyric acid	edestin	2.8–2.9	OKAHARA	1.5×10^{-5}
16	propionic acid	,,	2.9	,,	1.4×10^{-5}

From Table XIII it can be seen that even if the sort of protein used is different with different investigators, the optimum acidity with sulfuric, nitric, phosphoric, sulfosalicylic, oxalic and maleïc acids resembles that of hydrochloric acid. These acids have greater dissociation constants or the numbers are not determined because of their strong dissociations. And the decrease in the optimum hydrogen ion concen-

*The result of the study on the electric dissociation constant is given in the Appendix.

tration for digestion is seen with the acids with smaller dissociation constants. In other words, the decrease of the optimum acidity goes parallel with the decrease of the electric dissociation constant of the acid concerned. Even in such organic acids as oxalic and maleïc acids, where the dissociation constant is greater than 1.0×10^{-2}, the decrease in optimum acidity is not noticed. The decrease in optimum acidity for digestion is noticed first in malonic acid, the dissociation constant being 1.6×10^{-3}. The decrease of optimum acidity for digestion is greater for those of the fatty acid series with smaller electric dissociation constants, such as acetic, propionic and butyric acids, than for those with greater electric dissociation constants, such as tartaric, malic and citric acids. But in the case of formic acid, though the value of the dissociation constant is similar to those of lactic and malic acids, the optimum acidity for digestion is slightly different and is rather similar to that of acetic acid. Though not without some exceptions, it may generally be stated that i) *if a given acid is used, the optimum acidity for digestion is slightly different for different proteins* (RINGER, and LONG and HULL, and NORTHROP) (See Table I.), *and* ii) *if a given protein is used, the optimum acidity for digestion depends much on the sort of acid used, and its decrease is parallel with the decrease of the dissociation constant.* From i) and ii), therefore, it may be postulated that the difference in the optimum hydrogen ion concentration for digestion may be partly caused by the difference in combinations of acids with proteins in some way.

A few cases are known, where the results are seemingly divergent from the above generalisation. In the case of hydrochloric acid, the optimum reaction between various proteins and enzyme takes place at a nearly equal hydrogen ion concentration, i. e. at about pH 1.8–2.0, with some exceptions (See Table I). Also in the presence of oxalic, acetic, and citric acids (RINGER) the optimum reactions for digestion of serum are found at the same or at almost the same hydrogen ion concentration with that for edestin respectively, as may be seen from Table XIII. Such facts may be explained by the assumption that there are proteins which resemble each other in some points of chemical and physical properties, so that they are hydrolysed by pepsin under the effect of various acids at the same or almost at the same hydrogen ion concentration. These considerations lead us to the idea

that in the research of the digestion of protein by pepsin we should hereafter mention expressly the kinds of proteins and acids used.

III. SUMMARY.

In connection with the result of the experiments which were carried out to investigate the proteolytic enzyme of *Drosera*, the effect of various acids on the digestion of protein by pepsin was investigated. The results are summarized as follows.

1) The optimum acidities for digestion of edestin solutions acidified with hydrochloric, formic, acetic, propionic, butyric, oxalic, maleïc, malonic, malic, tartaric, and citric acids by pepsin, generally differ with the different kinds of acids.

2) The decrease in the optimum acidity for digestion is parallel, on the whole, with the decrease of the electric dissociation constant of the acid used (Table XIII and Fig. 12).

3) It is suggested that a difference in the combination of acids with proteins in any way may cause differences in optimum acidities for digestion by pepsin.

4) We may assume that the degree of dissociation of pepsin-substrate compounds is dependent upon the kind of acids used in the digestion experiments.

In conclusion the writer wishes to acknowledge his indebtedness to Prof. Dr. Y. YAMAGUTI for his valuable help and advice.

APPENDIX.

The Determination of the Electric Dissociation Constant of Sulfosalicylic Acid.

Since the electric dissociation constant of sulfosalicylic acid was not yet known, I endeavored to determine it from the electric conductivity of the solution. The technique adopted in the experiment was an ordinary one and the temperature was kept at 25±0.05°C. The molecular conductivity in any dilution is represented by μ, that of infinite dilution by μ_∞. The value of μ_∞ was calculated from the tables of BREDIG (1894) and WEGSCHEIDER (1902). And if v is the volume in liters containing one gram molecule of the acid, and α represents the degree of ionisation, the application of OSTWALD's dilution law gives us

$$k=\frac{\alpha^2}{(1-\alpha)v},$$

where k is the electric dissociation constant or the affinity constant. This number is frequently given in the hundred-fold value ($K=100\,k$), but the procedure of centuplication is not here taken for Table A.

TABLE A.

Sulfosalicylic acid, $HO_3S \cdot C_6H_3(OH) \cdot COOH$

$\mu_\infty = 375.$

v	μ	α	k
16	308.47	0.82071	2.35×10^{-1}
32	330.94	0.88252	2.07×10^{-1}
64	352.31	0.93950	1.85×10^{-1}
128	387.56	—	—
256	425.35	—	—
512	477.17	—	—
1024	552.54	—	—
2048	656.90	—	—

Table A shows that in a greater dilution than 128, the number k is impossible to be found, therefore it remains undetermined whether the dissociation of this acid obeys OSTWALD's dilution law or not. By the way, we find that the acid is such a strong electrolyte as sulfuric and phosphoric acids.

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Some Notes on the Physiology of *Styela clava* HERDMAN.[1]

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(With 8 text-figures.)

INTRODUCTION.

If one touches either siphon of ascidians, not only does that siphon close but the other siphon immediately closes. The correlation between such a reflex just stated and the central nervous system which is reduced in this group to a single ganglion, was studied by several investigators: J. LOEB (1891 & 1899) found in *Ciona intestinalis* that it exhibited the reflex even after the extirpation of the ganglion. On the other hand MAGNUS ('02) and FRÖHLICH ('03) showed that the ganglion extirpated ascidia exhibited no longer the reflex. JORDANN ('08) who also obtained the negative results interpreted the function of the ganglion differently from that of the former two authers. HECHT ('18) noted a rhythmic occurrence of the spontaneous movement of both body and siphons. I found the same phenomena which was found by HECHT in *Cynthia roretzi* and in *Styela clava*. The object of the present investigation is: as to how far the ganglion of *Styela* participates in such spontaneous movement.

Before going further, the writer wishes to express sincere thanks to Prof. S. HATAI for his kind direction.

MATERIAL AND METHOD.

Styela clava is found abundantly in the neighbourhood of our station. The body is somewhat spindle in shape with a long stalk in the posterior end, by means of which the animal attaches itself to the *Pecten* shell or rock. The test is brownish colored and is provided with small protuberances. In the most anterior part of the body, the two tubular siphons are situated side by side keeping a small distance

[1] Contributions from the Marine Biological Station, Asamushi. Aomori-Ken. No. 75.

(3 mm. to 5 mm.). The oral siphon is located in the ventral and atrial in the dorsal edge. In this species, the surface of the siphon are not lobed. The opening of the oral siphon is a little larger than that of the atrial, and the tentacles are to be seen at the region where the oral siphon attaches to the body (Fig. 1.).

Fig. 1. A medium sized specimen of *Styela clava*, showing view of left side. $\times \frac{2}{3}$.

The tentacles just stated are forty in number and are arranged like the spokes of a wheel, leaving a small space in its centre through which the water enters into the branchial sac. From either presence or absence of the tentacles the two kinds of siphons are easily distinguished when opend (see Fig. 8. tn.).

The materials were kept in a large fish pond. Although the animals normally live in the deep muddy bottom of the sea attaching itself to the *Pecten* shells or to the rocks, they appeared healthy and vigorous in this relatively shallow fish pond.

The general behavior of the animal was observed continuously in the laboratory without removing them from their natural attachment, *Pecten* shells or rocks, keeping in a large battery jar which was provided with running sea water. The movements of the animal were recorded on the drum of kymograph. In order to record the very feeble movement of the rim of the siphons, the animal was laid on heavy plate and the body was lightly enveloped with cotton and then bound excepting the anterior part. The levers were so arranged as to record the movement of both siphons simultaneously. *Styela clava* is highly sensitive to extraneous vibration and I was obliged to perform the present work in a completely isolated house of concrete floor.

EXPERIMENT.

I. Observation on unstimulated individuals.

Although I could not observe an individual in natural environment,

I found that the animal possesses no definite rule in the mode of the attachment to the shell of *Pecten*. When the animals are observed in the laboratory, they remain motionless with siphons wide open. A comparatively vigorous water current is seen entering the oral siphon, and leaving the atrial siphon. From time to time, however, the siphons and the body are contracted, and the water current is ceased. In these movements there are two kinds: 1) The oral siphon (most frequently, but not always) first closes, and then the rapid elongation of body takes place due to the contraction of the circular muscles, thus expelling the water of the branchial sac, followed by partial or complete closure of the atrial siphon. 2) Both siphons close simultaneously accompanied by the rapid contraction of the longitudinal muscles of the body wall. In this case the water in the branchial sac is not expelled in the course of the contraction. The movements of the siphons or the contracting circular muscles occur more frequently than the logitudinal contraction of the entire body. It is noticeable that in these two types of movements, the contraction of the one siphon is followed always by the contraction of other siphon.

Besides these two kinds of movements just stated, we often see partial contractions of one siphon which do not always close the other siphon co-ordinately. Such partial contractions of the siphons never occur when the animals are placed in the filtered sea water. Among the animals which exhibited frequently such behavior in the siphons, some possessed one or two parasitic crustaceae in the fold of the branchial sac. From these facts, the occurrences of the partial contractions are due probably to the stimulation of either siphon rims or tentacles by such foreign bodies as the particles or faeces suspended in the water, or the parasitic organism. All these movements mentioned above are clearly shown in the kymographic records (Figs. 2, 3).

The frequency of the spontaneous rhythmic movement shows individual variation; from 8 to 27 per hour. Even the same individual shows variation at different times. From my continued observations it became evident that the spontaneous rhythmic movement occurs especially when the animals are kept in the filtered sea water, contrary to the statements made by some authors (MAGNUS, FRÖHLICH, JORDAN, DAY.) who claim that movement of ascidians only occurs while expelling the foreign particles, faeces, sperms, ova and etc. through the atrial

Fig. 2. The spontaneous rhythmic movement of an intact animal. In running sea water. (Contraction upward). (Upper, contraction of oral siphon. Lower, contraction of atrial siphon.) Very short curves indicate the partial contractions of the siphons. Time marks, 5 min.

Fig. 3. The spontaneous rhythmic movement of an intact animal. In filtered sea water. (Upper, contr. of oral siph. Lower, contr. of atrial siph.) Time marks, 5 min.

siphon. HECHT (1918) suggested that such occurrence of the spontaneous movement may be the degenerate remains of an activity homologous with the rhythmic pulsation of the salpas. The real functional significance of the spontaneous rhythmic movement is not yet clear.

II. Responses to tactile stimulation.

Styela clava is stimulated preeminently by touching with a fine glass rod, but the test of the body is insensitive to a very gentle scratch.

If the outside of the siphon be touched very lightly, the only stimulated siphon will contract while the other siphon remains open. The siphon thus closed opens again immediately.

If, however, the stimulus be stronger, not only does the stimulated siphon close but the other siphon also closes. Following the closure of both siphons, the body contracts longitudinally ; the reaction which

has been generally regarded as the only reflex indicated by the ascidians.

On the other hand the stimuli given to the interior surfaces of the siphons call forth the different reactions than that mentioned above. For instances: if the inside of the siphon or one of the tentacles be touched as lightly as possible, the unstimulated siphon will partially contract, while the stimulated siphon remains open. If however the stimulus was slightly stronger, the unstimulated siphon is tightly closed, and the body wall circularly contracts, while the stimulated siphon contracts partially and then completely after ejecting water.

If the stimulus was still stronger the longitudinal contraction of body finally takes place after it has shown the responses already described. The last two reactions probably correspond to what JORDAN ('07) has reported in *Ciona* as the "Ejektionsreflex".

Furthermore, the two kinds of reflex: the reaction when the outside of siphon is stimulated and the reaction shown by the stimulation in the inside of siphon, are distinguishable in *Styela clava*. From these observations, it is clear that the rims of the two siphons and tentacles are the most sensitive areas than any other part of the body surface.

III. Response to Vibration.

Styela clava is extremely sensitive to vibration. An animal in a battery jar placed on a table in the laboratory, closes its siphon to the slight vibrations produced by walking across the floor, shutting the door gently, or tapping a jar. This high degree of sensitivity to the sound gave me considerable difficulty to observe the normal behavior of the animal. This difficulty was avoided in working on the concrete floor in an isolated house. It may be added here, that when the both siphons are amputated, the animal shows no more response to vibrations.

IV. Extirpation of the ganglion.

To extirpate the ganglion, only the test in the middle of the intersiphonal region is at first carefully opened in incising about 2 centimetres wide, so as not to injure the muscle layer till a small redish brown spot distinguished from the yellowish brown muscle layer, was noted. This spot is the neural gland to which the ganglion attaches itself directly beneath it. I removed the muscles surrounding the ganglion with a fine sharp scissor, or in some cases it was destroyed by applying a red-hot needle.

The animal thus operated opens both siphons within 5 or 6 hours after returned to the fresh water, while in an intact animal which was extraordinary disturbed but not injured the siphons open in less than half an hour.

The animal from which the ganglion was extirpated looks less expanded and the siphons do not open as widely as is the case with an intact animal. The kymographic records were taken after the lapse of more than a day after operation, when the shock from operation largely disappeared. In order to obtain the response to penciling and to tapping on the jar much greater strength was required compared with the normal intact animals. They are no longer disturbed by those extraneous vibrations from the closing of doors and treading of feet which produced responses readily prior to the operation.

Furthermore only the stimulated siphon shows response, and the other siphon remains opened; namely, the co-ordinative movement of the siphons, characteristic to the normal animal is completely lost.

The spontaneous co-ordinative movement shown by the both siphons are also disturbed to such an extent that the expelling of water in the branchial sac becomes difficult, due to their irregular and independent contrations. These disorganized movements of the siphons will be more distinctly seen in the kymographic records (Fig. 4).

Fig. 4. The spontaneous rhythmic movement after extirpation of ganglion. (Upper, oral siph. Lower, atrial siph.) Time marks, 5 min.

In an intact animal the frequencies of contractions shown by each siphon are practically identical, but in the operated, the frequencies

shown by one siphon differs considerably from that shown by the other, as will be seen from the following table.

TABLE

Number of frequency of each siphon per an hour.

Animal	Frequency of oral siphon	Frequency of artial siphon
I	8	19
II	8	13
III	10	5
IV	12	8
V	15	9
VI	24	19
VII	25	9
VIII	38	15
IX	39	29
X	54	15

As the table shows, the number of contractions shown by the oral siphon is far greater than that shown by the atrial siphon. Moreover, it was found that longitudinal or circular contraction of the body wall seldom occurs in operated animals. Accordingly, an adequate functioning of ejecting the foreign bodies which entered into the oral siphon becomes impossible after operation. Whether all these changes in the reaction seen in the operated animal are due to the result of extirpation of the ganglion or due to unavoidable severing of the muscular connections needs further consideration. To decide this point in question I made the following experiment: I have severed the muscular connection near the ganglion lengthwise for about two centimetres, leaving the ganglion intact. The animals so operated show all activities which are characteristically seen in an intact animal. The spontaneous rhythmic movement of the siphons occur co-ordinatively as is shown in Fig. 5. Thereupon, it seems evident that the ganglion controls the co-ordinately movement of the both siphons.

V. Amputation of siphons.

If one siphon is suddenly amputated with a scissor, and both the animal and the amputated piece are put into fresh sea water, the

Fig. 5. Muscular connection between both siphons severed, ganglion being intact. (Upper, oral siph. Lower, atrial siph.) Time marks, 5 min.

other intact siphon open within less than an hour, while the isolated siphon does not open until five or six hours after the amputation.

Although the isolated siphon is capable of responding to tactile stimulation, but it required a stronger stimulation than the siphon attached to the animal from which the ganglion was extirpated.

The kymographic records taken from the isolated siphon: oral or atrial, shows an automatic rhythm, but that of the oral siphon is very vigorous (Figs 6, 7).

Fig. 6. Automatic contraction of Amputated oral siphon. Time marks, 5 min.

Fig. 7. Automatic contraction of Amputated atrial siphon. Time marks, 5 min.

The forms of curves shown by the isolated oral siphon resemble those of the siphons of the ganglion extirpated animal. In *Styela*

clava the amputated portion of the siphon is regenerated completely in the course of about two weeks, but isolated piece survives only two or three days after amputation.

THE MUSCULATURE OF THE SIPHONS AND THE BODY WALL.

If both the test and thin membraneous mantle which lies immediately inside of it are removed, a redish yellow muscle layer is found running circularly, and obliquely. A part of the circular muscle fibres surrounds the basal region of oral siphon and the other part surrounds that of the atrial siphon independently. The muscles located in deeper layer runs longitudinaly and then continues with the longitudinal muscle bundles found in the wall of the siphon. In both siphons the longitudinal muscle layer lies nearer to the outer margin while the circular muscle layer which consists of large rings of muscles is in the inside. Both the inner and outer margins are covered by the mantle and test. The stalk contains both kinds of muscle bundles, longitudinal and circular, but decrease gradually and beyond the middle portion of the stalk, no more muscle fibres are found being composed of only mantle and test.

ANATOMY OF THE INTERSIPHONAL REGION.

The general structure of the intersiphonal region may be conveniently observed from the internal side without removing the muscle layer. For this purpose the cross section of the anterior portion of the body or further below the intersiphonal area is made from the formalin preserved specimen, and is examined from cut surface. From the section the wall of the branchial sac is carefully removed. Then by aid of lens one sees a white mass of horse-shoe shaped, which is situated near to the oral siphon and a little on the right side. This mass is the ciliated funnel. The ciliated funnel continues with the duct of the neural gland which runs along the ventral side of the ganglion. The careful removal of the duct brings a white elongated ganglion to sight. The length of the ganglion is 2–2.5 mm. in medium sized animal, about a half of the distance between both siphons. It is bifurcated at both ends and the great siphonal nerves arise from these ends. Both oral-siphonal nerves run along the right and left

side of the base of the oral siphon respectively. A branch is given off from the right oral siphonal nerve which runs immediately into the wall of the siphon. The left nerve also gives off a branch to some distance from the base and runs into the wall of the branchial sac. The right atrial siphonal nerve is again bifurcated and one branch enters into the wall of the atrial siphon and the other into the body wall. The left atrial siphonal nerve is trifurcated and all of these run into the wall of the atrial siphon. The distribution of the nerves described above is diagramatically shown in Fig. 8.

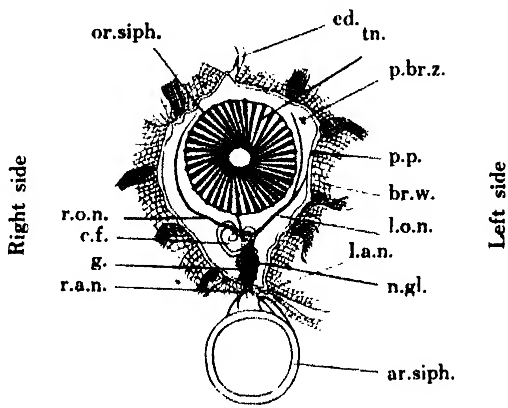

Fig. 8. A diagramatic sketch of the intersiphonal region from internal side.

ar.siph.; atrial siphon
br.w.; branchial wall
c.f.; ciliated funnel
ed.; endostyle
g.; ganglion.
l.o.n.; left oral siphonal nerve
l.a.n.; left atrial siphonal nerve
n.gl.; neural gland
or.siph.; oral siphon
p.br.z.; peribranchial zone
p.p.; peripharyngeal band
r.o.n.; right oral siphonal nerve
r.a.n.; right atrial siphonal nerve
tn.; tentacle

SUMMARY.

1. *Styela clava* shows two kinds of the spontaneous rhythmic movement.

2. The species is very sensitive to tactile stimulation, and manifests many characteristic reactions depending on the kinds of the stimulus given. The rims of siphon and the tentacles are most sensitive.

3. *Styela clava* is also very sensitive to vibrations.

4. In *Styela clava* from which the ganglion was extirpated (1) the sensitivity is greatly reduced and (2) some of reflex are completely lost.

5. The amputated siphons are regenerated in the course of two weeks after the operation. The amputated piece of siphon is capable of responding to tactile stimulation, and possesses automatic rhythm of the contraction.

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Correlative Study on the Histological and Biochemical Changes in the Experimental Hydronephrosis with Reference to the Pelvic Fluid, Urine and Blood in Their Relation to the Renal Parenchym.

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(With Plates XVI – XVIII and 13 text-figs.)

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CONTENTS.

I. INTRODUCTION AND HISTORICALS.

The fact has already been noticed and studied by some investigators such as VIRCHOW ('63), COHNHEIM ('78), SIMON ('79), LANDOIS ('88) etc., both clinically and pathologically, that hindrances in the urinary passage led to hydronephrotic alteration on the side and at the same time to compensatory hypertrophy of the sister kidney. Thereafter, the study of hydronephrosis became a favorite subject among investigators and a great deal of literature has been accumulated, especially on the histological studies. With regard to the biochemical studies, especial the studies carried out correlatively on the biochemical as well as on the histological changes of the organ or tissues in the same pathological conditions, there are but few, as far as I am aware.

So far as there are some definite histological changes, it may be inferred that there must certainly also be some essential changes in the chemical components as well. If we can correlate the chemical changes in the organ or tissues undergoing some pathological alterations with the histological pictures in the same conditions, then we can get a clearer understanding of the essentials of the disease, and thus we may also anticipate the principles of the preventions as well as the treatments for it.

It is just this idea which made me attack this problem, histologically and biochemically; the problem of the kidney whose ureter was obstructed, and the hypertrophied sister kidney, with special reference to the chemical constituents of the stagnant pelvic fluid in hydronephrosis and other body fluids, for a clearer understanding of the renal function.

Before presenting the results of my own reseaches on the subject, it will be worth while to abstract the representative opinions.

As to the genesis of hydronephrosis, there have been many opinions

from earlier times. COHNHEIM ('82) carried out an experiment on dogs and rabbits, and concluded that complete ureteral obstruction led to atrophy of the kidney, but never led to large hydronephrosis, due probably to a decrease of urine secretion caused by a strong disturbance of the blood circulation accompanied by an ever increasing pressure in the pelvis by the sudden ureteral obstruction, while the incomplete ureteral obstruction, such as by loose ureteral ligature and intermittent hindrance in the urinary passage, led to hydronephrosis of a high degree, due probably to the fact that the disturbance of the blood circulation in ureteral stenosis was not great as in the complete ureteral obstruction, and the influence upon urine secretion was also not so striking.

FRAENKEL ('01), FABIAN ('04), PONFICK ('10), SUZUKI ('12) etc., also observed hydronephrosis of a high degree in ureteral stenosis, while GUYON ('90), ARNOLD ('90), ALBARRAN ET LÉGNEU ('91), TUFFIER ('93), KAWASOE ('12), SCOTT ('13) etc., insisted that they observed hydronephrosis of a high degree in the complete ureteral obstruction. LINDEMANN ('98) reported that there were two different forms in the changes of the renal parenchym in the ureteral obstruction, namely, cases which showed chiefly parenchymatous atrophy, but not hydronephrosis, and cases which showed atrophy as well as hydronephrosis with serous fluid as its content.

In some cases of the ureteral stenosis, he observed hydronephrosis of a high degree. Therefore, he concluded that such an inconstancy in the results was not only due to the methods of the ureteral ligature or the degree of stenosis, but also due probably to whether the anastomosis among the vascular systems of the kidney and its environs was complete or not.

As to the fate of the kidney whose ureter was ligatured, there were many different opinions, as is obvious from the above description.

Even in the complete ureteral obstruction, some insisted that they observed hydronephrosis of a high degree, while others maintained that they found atrophy of the organ without accompaning hydronephrosis.

Accordingly, FRAENKEL ('01), KAWASOE ('12), OSHIMA ('18), HOZUMI ('22) etc.; examined the relation between the formation of hydronephrosis and the method of the ureteral ligature, and they could produce mostly hydronephrosis of a high degree in the complete ureteral

obstruction, maintaining the blood circulation of the kidney intact. HOZUMI also succeeded in producing a typical hydronephrosis by the complete ureteral obstruction as well as by the stimulation of the kidney with bacteria, chemicals and concrements.

It has also been an important question to determine at what period and to what degree its sister kidney could compensate for its disturbed function, when a kidney could not fulfil its function from various causes, or when it was extirpated. There have also been many investigators already on this subject such as, SCHILLING, FRISCH and ZUCKERKANDL, WILDBOLZ ('11), MARINACCI ('11), SUGIMURA ('15), AKAIWA ('15), KAWAI ('24), FURUYA ('25) etc.

It is generally believed that when the function of a kidney was disturbed or was put out of its function, the sister kidney could compensate for its function to some extent and thus be led to compensatory hypertrophy. The question still remains to be solved whether all the parts of the sister organ are responsible for fulfilling the increased function and again whether the enlargement of the organ is caused only by hypertrophy or by hyperplasia. A search shows that several investigators have attempted to answer this question, for instance, SIMON ('76), GUDDEN ('76), BEUMER ('78), GRAWITZ and ISRAEL ('79), LEICHTENSTERN ('81), ECKARDT ('88), YAMAGIWA ('89), ENDERLEN ('89), RIBBERT ('96), SACERDOTTI ('96), SAUER ('97), CHAUFFARD ('98), ASCHOFF ('00), GALEOTTI and VILLA-SANTA ('02), MANCHELE ('94) and many others.

I shall, however, not attempt to cite the views held by the authors just mentioned as they are but little related directly with my own present work.

As to the biochemical studies I shall cite those papers which are concerned with the present work. WEIGERT ('85) who studied the changes undergone by dead tissues under various conditions noticed a disappearance of nuclei of cells during coagulation-necrosis.

KLEBS ('90) noted, in the destruction of the nuclei by mycotic processes, two forms of nuclear changes: karyolysis and karyorrhexis.

SCHMAUS and ALBRECHT ('95) observed that after ligation of the renal blood vessels the first change was pyknosis, followed by karyorrhexis, which however presents numerous intermediate variations between this and necrobiosis. With regard to the biochemical changes

of the spleen during autolysis, there were relatively many investigations as by Levene ('04), Schumm ('03), Hedih ('03) etc., and moreover, Corper ('11) studied histologically and chemically the changes in the dog's spleen during autolysis in vitro and in vivo and he noted most marked chemical changes in a disintegrating spleen during karyorrhexis and karyolysis: and even when microscopical nuclear disintegration was practically at an end, the chemical process of disintegration was still going on, though very slowly. Simon ('14) studied the autolytic phenomenon of the kidneys in the rabbits chemically and observed that incoagulable nitrogen and soluble phosphorus in antiseptic autolysis of the normal kidneys increased to about three times those of the control (dissolved N and P from renal sample previously boiled), while the autolytic proteolysis and phosphorus decomposition was strongly hindered in the nephritic kidneys.

We further find a list of names of investigators who studied the kidney of various animals chemically under various conditions: Stockhausen ('09) examined the chemical compositions of the kidney of the dog. Magnus-Levy ('10) carried out chemical analysis on the normal human kidney. Bleyer and Berger ('24) studied the chemical composition of the normal kidney of the rabbit. Nuzum and his co-workers ('24) determined the lipoid content of the kidney, after poisoning with uran nitrate, in the rabbit. Schnapp ('24) determined also the lipoid content in the degeneration of renal cells in the guinea-pig.

The present work was carried out at the Biological Institute of the Tôhoku Imperial University, and the laboratory facilities were generously placed at my disposal through the special courtesy of Professor Dr. Shinkishi Hatai, Director of the Institute.

It is my pleasant and reasonable duty to take this opportunity to express my profound gratitude for the courtesy and also for his manifold kindnesses in inspiring direction, continual encouragement and careful reviewing of the manuscript.

I wish also to express my cordial thanks to Professor Dr. Shichitarô Sugimura for his valuable advice and critique on the many aspects of the work.

Acknowlegement should be made also to the other professors and members of the Institute for their friendliness and help, which enabled

me to work there comfortably. As to the biochemical side of the work, I owe much to the late Assistant Professor KATSUMI OKAZAKI, for whom I wish here to express my sincere appreciation of his friendly benefaction.

II. MATERIAL AND METHODS.

In all experiments rabbits were used as material. For two weeks before operation, the animals were kept on a definite diet (2–300 g. "Tofu-kara" or soja-bean residue, corresponding to about 7.3–11.2 g: protein), and under as uniform conditions as possible, and their health was ascertained.

For the operation, the left side of the abdomen of the rabbit was shaved and brushed with tincture of iodine, then under ether narcosis the regio abdominalis lateralis was opened, and the left ureter was then firmly double ligatured in two places about one centimetre apart from one another, and about 2 and 3 centimetres from the renal hilum respectively. The wound was then sewed together, and again brushed with tincture of iodine, thus completing the operation. Blood sample from the blood vessel of the ear, urine which was taken by a cathether, and the body weight was examined at definite intervals before and after operation. The animals, which were allowed to live for a definite number of days after the operation, then were killed with a blow on the head, and after evisceration both kidneys were at once carefully removed, and each was weighed separately in a closed weighing bottle.

Finally, the length (longest diameter), the width (distance between the hilum and crest), and the thickness (at the level of the hilum) were all measured with sliding calipers. The animals which died unexpectedly were treated in the same manner as soon as possible.

The samples of the remaining obstructed kidney, from which the stagnant pelvic fluid was collected, and those of the sister kidney of the opposite side and the normal kidney were employed partly for histological study and partly for chemical study. The pelvic fluid thereby collected was prepared for chemical study also.

For the histological study of the samples, fixation in formalin and alcohol was followed by embedding in paraffin and celloidin. The

plane of the section was mostly parallel to the long axis of the kidney and through the renal hilum, and thus the sections were made.

DELAFIELD's haematoxylin-eosin and VAN GIESON's method were used for the general staining, while WEIGERT's method was employed for elastic fibres.

For the biochemical study of the remaining samples of the normal, obstructed and compensatory hypertrophied kidney, the following subjects and methods were chosen: (1) water content, (2) dry substance, (3) organic substance, (4) inorganic substance, (5) total nitrogen by micro-KJELDAHL, (6) chlorine, as sodium chloride, by VAN SLYKE and (7) ether alcohol soluble substances from fresh materials.

For the biochemical study of the urine and pelvic fluid, the following methods were employed:

(1) pH .... by quinhydrone electrode.
(2) Specific gravity .... by pycnometer.
(3) Depression of the freezing point.... by BECKMANN's micro apparate.
(4) Total nitrogen .... by the micro-method of KJELDAHL.
(5) Urea nitrogen .... by FOSSE's method with xanthydrol.[1]
(6) Ammonia nitrogen .... after FOLIN.
(7) Protein nitrogen .... by the micro-method of KJELDAHL.
(8) Sodium chloride .... after VAN SLYKE.[2]
(9) Water content. (10) Dry substance, (11) Organic substance.
(12) Inorganic substance. (13) Creatinine by the micro-method of FOLIN.

The urine was collected with a catheter before and after the operation and the pelvic fluid was collected with a syringe, care being taken to avoid the contact of the fluid with the blood. For the estima tion of the total nitrogen, ammonia nitrogen and NaCl of the pelvic fluid the sample was employed, as it was; for the determination of protein nitrogen, precipited substance by adding three volumes of 5 per cent. trichloracetic acid were used, and the filtrate obtained thereby, was used for urea and creatinine determination.

Blood. We can comprehend the real state of the renal function only after carefully examining the components of the urine, which are secreted by the kidney as a result of metabolism, as well as those substances which are retained in the body, especially in the blood. As the blood normally has a more fixed nature, though the change

[1] Feigl: Zeitschr. f. d ges. exp. Med. Bd. 12, S. 13, 1921.
[2] J. Biol. Chem. Bd. 58, S. 523, 1924.

in the blood is not usually so remarkable as that in the urine, its change, if any, is of more value than that of the urine for the judgement of the renal function. Among the components of the blood, non-protein nitrogen and urea are the most important for the examination of the renal function. It is very regrettable that AMBARD's coefficient can not be applied here, for the calculation of the latter requires the diurnal amount of urine, the collection of which, especially in a pure condition, is very difficult and almost impracticable to carry on simultaneousely in connection with other work on small animals like rabbits. The blood sample was taken from the blood vessel of the ear before and after the operation, and then made protein-free after FOLIN and WU,[1] and determined as follows:

(1) Non-protein nitrogen ....by micro-KJELDAHL.
(2) Urea nitrogen .... by FOSSE's method with xanthydrol.
(3) Sodium chloride ....by VAN SLYKE's method.
(4) Creatinine ....by FOLIN's method.

III. OBSERVATIONS ON THE NORMAL AND EXPERIMENTAL ANIMALS.

(A) Normal Rabbits (as a control).

1. The Relation between the Weights of the Body and the Kidney.

After the unilateral ureteral ligature the kidney concerned increases its weight and volume up to a certain point, then decreases gradually. When the renal function is disturbed in the kidney of one side, the sister organ of the opposite side shows a compensative increase of function and enlargement, so that the weight and volume of the obstructed kidney after its ureteral ligature can not be rightly compared directly with that of the sister organ. I have determined the weight of both kidneys separately, using 17 normal adult rabbits, and found that the sum of the weight of both kidneys equaled 0.656% of the body weight (relative weight of the kidney) and that of one kidney equaled 0.328%, thus the weights of right and left kidneys were practically equal, as is shown in Table I. and Fig. 1.

The relative weight of the kidney in percentage of body weight mentioned above (0.328%) is almost exactly similar to that determined

[1] J. Biol. Chem. 58, 523, 1924.

by Ponfick (0.325%), which was cited by Oshima ('18) and Hozumi ('22) and that by Bleyer and Berger ('24). The relative weight of the kidneys of the albino rat, according to Hatai's formula ('13) and his data, is 0.9% of the body weight at 5 g. in the new-born male albino rat, which increases to a maximum of 1.53% at 10 g., then decreases to 1.38% at 20 g., and finally it reaches 0.80% at 400 g., while Jackson ('13) found slightly larger values in respective ages of the rat. In the dog, it is given by Kaethe Witch as 0.48%; in man it is 0.62% (G. Kato).

Concerning the weight of both kidneys, it is believed that the left kidney is heavier in man and in the rabbit, while in the rat the right

Table I.

Relation between the weight of bodies and kidneys and the size of kidneys. (normal)

Serial number of rabbit	Body-weight (g.)	Kidney-weight (g.)		Absolute values in (mm)					
				length		breadth		thickness	
		R.	L.	R.	L.	R.	L.	R.	L.
15	1125	4.1	4.0	25	25	17	16	08	09
49	1530	5.5	5.6	28	27	17	20	12	11
28	1650	5.5	5.5	28	28	20	20	12	12
16	1800	5.8	5.8	26	27	18	16	11	12
8	1800	6.6	6.4	28	27	18	19	10	11
17	1810	6.3	6.7	28	28	19	18	12	11
12	1860	6.0	6.5	29	28	18	19	11	10
13	1890	7.5	7.0	30	29	20	19	13	14
11	1900	6.8	6.6	28	28	18	19	10	12
1	1955	5.5	5.5	27	27	20	19	09	10
41	1980	7.2	6.9	29	30	22	22	12	13
22	2000	6.7	6.7	28	28	20	19	12	11
52	2000	7.0	7.0	30	30	21	19	13	13
38	2080	6.8	6.8	30	30	20	20	10	12
26	2080	7.2	7.5	30	30	22	23	13	13
14	2300	7.5	7.2	31	31	19	20	11	10
21	2410	6.5	6.5	29	29	19	18	12	11
Average	1955	6.4	6.4	28.5	28.3	19	19	11.2	11.5
Total average		6.4		28		19		11	

kidney in both sexes is slightly heavier than the left, by 2.1% in the male and 2.3% in the female (ARATAKI, '26). My own observation of the rabbit showed, contrary to the above statement, that the weights of both kidneys are practically identical.

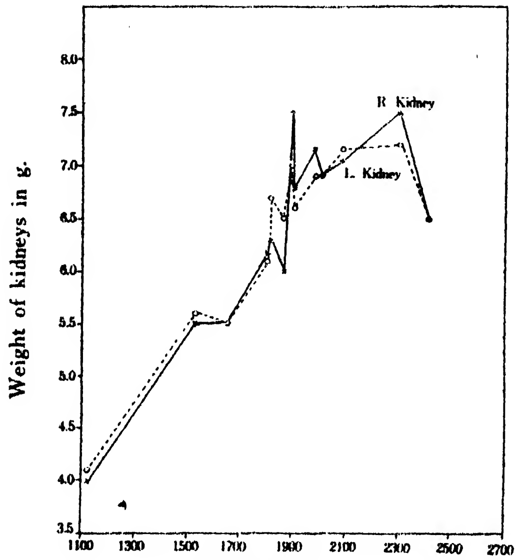

Fig. 1. Showing the relation between the body weight and the weight of the kidneys.

2. Diurnal Amount, Specific Gravity and Reaction of Urine.

It is a well-known fact that the amount, specific gravity and reaction of urine differs considerably according to the age, body weight, season, diet, and other conditions, even in the same animal.

In the present study animals were fed entirely with "Tofu-kara" or soja-bean residue (2–300 g. daily), and the diurnal amount of urine, which was collected in the bottle attached to the floor of the cage, the specific gravity, the reaction, and body weight were examined at definite intervals, and a considerable fluctuation in their values was found.

The urine was turbid and yellowish white and its reaction alkaline. The average diurnal amount was about 143 cc. after feeding with definite diet for several days, though it showed very considerable

TABLE II.

Findings in the normal urine (not collected by catheter).

Serial number of rabbit	Weekly collection of urine (in week)	Average of urine quantity (cc. per day)	Average specific gravity	Body weight at the end of the week (g.)	Change, body weight in the week (g.)
2	0		..	2133	
	1	116	1.022	2340	207
	2	129	21	2320	−20
	3	89	20	2330	10
	4	157	19	2355	25
	5	146	20	..	
	Average	127	1.020		
3	0	..	..	2272	
	1	118	1.021	2375	103
	2	138	22	2490	115
	3	157	18	2475	−15
	4	158	19	2450	−25
	5	140	19	..	
	Average	140	1.019		
4	0	..	..	2082	
	1	135	1.022	2190	109
	2	127	20	2205	15
	3	91	22	2210	5
	4	111	20	2200	−10
	5	107	20	..	
	Average	114	1.020		
5	0	..	..	1900	
	1	58	1.021	1755	−145
	2	133	18	1830	75
	3	64	19	1910	80
	4	39	19	1890	−20
	Average	73	1.019		
6	0		..	1520	
	1	139	1.022	1805	285
	2	186	19	1805	45
	3	161	20	2025	175
	4	182	18	2075	50
	5	199	18	..	
	Average	173	1.019		
7	0	..	..	1675	
	1	108	1.021	1795	120
	2	133	19	1680	−115
	3	125	18	1720	40
	4	138	17	1860	140
	5	168	19	..	
	Average	134	1.019		
Average		143	1.019		

fluctuation at first. According to SERIO ('23) it was about 100 cc., while according to BERNET ('22) it was 200 cc. in the case of rabbits. The specific gravity was 1.018–20. The pH was 7.15 in the urine collected with a catheter and the specific gravity was 1.015 thereby; the depression of the freezing point was 1.02. The total nitrogen content was about 900 mg in 100 cc. According to BERNET it was about 520 mg. in the normal and about 693 mg. in the spleenless rabbits, while according to SERIO it was 522 mg. in the rabbits fed with milk.

The results of my own investigation are given in the following table:

3. Biochemical Findings of the Kidney.

Since data on the chemical composition of the kidney of the normal

TABLE III (1)

Biochemical findings in the kidney of the normal rabbit.

Serial number of rabbit	Body weight of rabbit (g.)	Absolute weight of kidneys (g.)		Water content of kidneys (%)		Dry substance of kidneys (%)		Organic substance of kidney (%)	
		Right	Left	Right	Left	Right	Left	Right	Left
15	1125	4.0	4.1	78.41	77.73	21.59	22.27	20.04	20.80
49	1530	5.5	5.6	77.56	77.60	22.44	22.40	20.58	20.21
28	1650	5.5	5.5	77.96	77.48	22.04	22.52	20.15	20.41
16	1800	5.8	5.8	79.10	79.80	20.90	20.20	19.64	18.78
8	1800	6.5	6.4	77.64	78.31	22.36	21.69	21.09	20.37
17	1810	6.3	6.7	—	—	—	—	—	—
12	1860	6.0	6.5	76.46	74.94	23.54	25.06	20.03	23.41
13	1890	7.5	7.0	81.77	81.20	18.23	18.80	17.01	17.50
11	1900	6.8	6.6	78.24	77.68	21.76	22.32	20.13	20.86
1	1955	5.5	5.5	79.15	79.51	20.35	20.49	19.36	20.05
41	1980	7.2	6.9	75.18	74.46	24.82	25.54	23.32	24.15
22	2000	6.7	6.7	77.73	78.05	22.27	21.95	20.40	20.37
52	2000	7.0	7.0	77.13	76.63	22.97	23.37	21.51	22.07
38	2080	6.9	6.8	74.91	74.65	25.09	25.35	22.53	23.94
26	2080	7.2	7.5	75.17	74.96	24.83	25.04	23.47	23.78
14	2300	7.5	7.2	76.60	77.17	23.40	22.83	22.08	21.59
21	2410	6.5	6.5	76.86	76.81	23.14	23.19	21.67	21.75
Average	1955	6.4	6.4	77.49	77.37	22.49	22.61	20.82	21.25
		6.4		77.43		22.55		21.07	

rabbit directly referable to my present work could not be found. I have for myself determined the water content, the contents of the dry substance, the organic substance, the inorganic substance, the total N, chlorine and ether alcohol soluble substances in both kidneys of 16 normal rabbits. The findings obtained are as follows:

TABLE III (2)

Biochemical findings in the kidneys of the normal rabbit.

Serial number of rabbit	Inorganic substance of kidneys (%)		Total N of kidneys (%)		Total N of dry substace (%)		Total N of dry substance excluding fatty substances (%)	
	Right	Left	Right	Left	Right	Left	Right	Left
15	1.55	1.50	2.898	2.920	13.43	13.12	17.74	17.63
49	1.86	2.19	2.420	2.763	10.79	12.33	14.29	17.00
28	1.89	2.11	2.223	2.691	10.09	11.95	16.93	16.18
16	1.44	1.42	2.862	2.781	13.69	11.09	20.59	18.37
8	1.27	1.32	2.808	2.709	12.56	12.49	17.73	16.63
12	1.51	1.65	3.492	3.483	14.83	13.98	22.62	21.32
13	1.22	1.28	2.772	2.754	15.21	14.65	22.56	22.12
11	1.63	1.46	3.375	3.411	15.52	15.28	23.72	20.14
1	1.49	1.44	3.015	3.087	14.82	15.06	—	—
41	1.50	1.39	2.880	2.682	11.60	10.50	16.86	15.62
22	1.87	1.68	2.826	2.655	12.69	12.10	18.20	16.50
52	1.46	1.30	3.249	2.988	14.14	12.78	19.32	17.34
38	1.56	1.41	2.628	2 961	10.48	11.68	15.21	16.14
26	1.36	1.26	2.573	2.916	10.36	11.64	13.68	16.78
14	1.32	1.24	2.961	2.979	12.65	13.04	18.95	19.44
21	1.47	1.44	2.916	2.754	12.61	11.87	18.10	17.10
Average	1.52	1.50	2.867	2.908	12.84	12.91	18.43	17.95
	1.51		2.888		12.88		18.19	

As is seen from the above table, the values show in general a somewhat remarkable fluctuation among the individuals, though those between both kidneys in the same individual show far less fluctuation. *Water Content.* The water content fluctuates between 81.77% and 74.91% in the right sister kidneys of the different animals, showing 77.49% on the average, and it fluctuates also between 81.20% and 74.65% in the left kidneys, showing 77.37% on the average. The total average of both kidneys is 77.49%. However, the water content

TABLE III (3)

Biochemical findings in the kidneys of the normal rabbit.

Serial number of rabbit	NaCl of kidneys (%)		NaCl of dry substance (%)		NaCl of dry substance excluding fatty subst. (%)		Fatty substances of fresh substance (%)		Fatty substances of dry substance (%)	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
15	0.25	0.24	1.16	1.08	1.53	1.41	5.25	5.70	34.32	25.65
49	0.14	0.14	0.62	0.63	0.82	0.89	5.50	6.52	24.50	29.11
28	0.27	0.28	1.22	1.22	1.62	1.72	8.91	5.89	40.42	26.15
16	0.25	0.24	1.34	1.26	2.01	1.86	7.00	6.55	33.49	32.42
8	0.45	0.46	1.87	1.92	2.58	2.42	6.52	5.40	26.93	22.59
12	0.39	0.29	1.65	1.15	2.52	1.76	8.10	8.72	34.41	34.80
13	0.26	0.27	1.42	1.43	2.10	2.15	5.95	6.35	32.64	33.78
11	0.52	0.56	2.39	2.50	3.29	3.65	7.53	5.38	34.61	24.11
1	0.21	0.22	1.32	1.05	1.88	1.47	—	—	—	—
41	0.16	0.25	0.64	0.99	0.74	1.47	7.74	8.37	31.20	32.77
22	0.11	0.23	0.49	1.00	0.82	1.35	6.74	5.86	29.18	26.69
52	0.36	0.46	1.55	1.94	2.09	2.63	6.16	6.14	26.81	26.27
38	0.11	0.21	0.43	0.84	0.62	1.24	7.82	8.01	31.17	31.60
26	0.13	0.11	0.50	0.42	0.66	0.64	6.02	8.64	24.25	34.36
14	0.23	0.26	0.98	1.13	1.47	1.68	7.78	7.51	32.24	32.90
21	0.12	0.39	0.54	1.67	0.77	2.39	7.00	7.09	30.27	30.55
Average	0.25	0.29	1.19	1.25	1.61	1.79	6.93	6.81	30.49	29.58
	0.27		1.22		1.70		6.87		30.04	

shows far less difference between the right and left kidneys of the same individual, suggesting strongly that the water content is influenced by the age of the animals. According to MAGNUS-LEVY ('10) the water content of the kidney is 75,6% in man, while according to BECHHOLD ('19) it is 77–83.7% in man, 85.7% in a new born infant and 84.8–88.2% in a nephritic patient. According to WOODS ('76) it is 77.11% in the kidney of the cow. It is given by STOCKHAUSEN ('09) as 76.11% in the dog fed with rice and 72.2% in that fed with flesh, but he fails to give the ages of the dogs employed. It is given by BLEYER and BERGER ('24) as 82% in the normal rabbit.

Organic Substance. The content of the organic substance fluctuates between 17.0% and 25.32%, showing 20.82% on the average, in the right kidneys. It fluctuates also between 17.5% and 24.15%, showing

21.25% on the average in the left kidneys. The total average of both kidneys amounts to 21.07%.

Inorganic Substance. The content of the inorganic substance ranges between 1.27 and 1.89%, amounting to 1.52% on the average in the right kidneys, and it also ranges between 1.28 and 2.19%, amounting to 1.50%, in the left kidneys. The total average of both kidneys amounts to 1.51%.

Total Nitrogen. The total nitrogen content of the fresh kidney rages between 2.420% and 3.492%, amounting to 2.867% on the average in the right kidneys, and it ranges also between 2.691% and 3.483%, amounting to 2.908% on the average, in the left kidneys. The total average of both amounts to 2.906%. The total N content is given by MAGNUS-LEVY as 2.82% in the fresh kidney, 3.058% in the fresh muscle and 2.500% in the heart-muscle of man. According to SATO it is 3.35–3.60% in the leg muscle of the rabbit.

The total N content in the dry substance ranges between 10.09% and 15.52%, amounting to 12.84% on the average, in the right kidneys, and it ranges also between 10.50% and 15.28%, amounting to 12.91% on the average, in the left kidneys. The total average of both kidneys amounts to 12.88%. The total N content of the dry substance, excluding ether-alcohol soluble substances, ranges also between 13.68 and 23.72%, amounting to 18.43% on the average, in the right kidneys, and it ranges between 15.62 and 22.12%, amounting 17.95% on the average, in the left kidneys. The total average of both kidneys amounts to 18.19%.

According to MAGNUS-LEVY the content of the total nitrogen in the fat free dry substance is 14.7% in the human kidney. According to SATO it is 14.32–15.49% in the leg muscle of the rabbit. The rather high value of the total nitrogen content given in the fat free dry substance are due undoubtedly to the presence of a somewhat larger amount of soluble non-protein in the ether-alcohol extract, which extract was deduced by calculation from the total solids as the nitrogen free fraction. Indeed I have actually found as much as 0.7–0.8% of nitrogen in such an ether-alcohol extractive.

Chlorine. The chlorine content such as sodium chloride of the fresh kidney ranges between 0.11 and 0.52%, amounting 0.25% on the average, in the right kidneys, and it ranges also between 0.11 and

0.56%, amounting to 0.29% on the average, in the left kidneys. The total average of both kidneys amounts to 0.27%. According to MAGNUS-LEVY it is 0.34% in man and according to LANDOIS ('00) it is 0.45% in the dog.

The content of the sodium chloride in the dry substance amounts to 1.19% on the average in the right kidneys and it also amounts to 1.25% on the average in the left kidneys. The total average of both kidneys amounts to 1.22%. Similarly the sodium chloride content in the dry substance free from ether-alcohol soluble substance amounts to 1.61% on the average in the right kidneys, and it also amounts to 1.79% on the average in the left kidneys. The total average of both kidneys amounts to 1.70%.

Ether-alcohol Soluble Substance. Tee content of the ether-alcohol soluble substances in the fresh kidney shows also remarkable fluctuation, as do most of the other substances. The content ranges between 5.25% and 8.10%, amounting to 6.93% on the average, in the right kidneys, and it ranges also between 5.38% and 8.64%, amounting to 6.81% on the average, in the left kidneys. The total average of both kidneys amounts to 6.87%. The fat content of the kidney is given by MAGNUS-LEVY as 5.2% in man. The content of ether-alcohol soluble substances in the dry substance fluctuates between 24.25% and 40.42%, amounting to 30.49% on the average, in the right kidneys, and it also fluctuates between 25.56% and 34.36%, amounting to 29.58% on the average, in the left kidneys. The total average of both kidneys amounts to 30.04%.

According to RUMPF, the fat content of the human kidney fluctuates between 23.67% and 34.30% in the dry substance.

4. Number and Size of the Glomeruli.

The distribution and the size of the glomeruli of the normal kidney of the rabbit were observed in both kidneys of the normal and operated animals, with a view to determining to what extent they were affected in various stages of the hydronephrotic process.

The number and size or diameter of the glomeruli in five normal animals was as follows:

As is shown in Table V, the average diameter of the glomeruli is 96 μ in my own cases, according to OKABE ('18) it is 99 μ in the rabbit; while it is given by BOYCOTT ('11) as from 33 to 23 μ, a

TABLE IV.

The number of the glomeruli in the microscopical field (4.3 sqmm.) (Leitz. Obj. 3.0 c. 1 × 51.) (the average value for 10 microscopical fields) (Obj. 1 ; Oc. III).

Serial number of rabbit	13		14		17		28		52	
Side of kidney	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.
Average	28	30	37	34	32	35	29	25	33	37
Average of averages	32									

TABLE V.

The average value of the diameter of the glomeruli (unit : μ) (Average value in 10 glomeruli) (Leitz. Obj. 7 ; Oc. I. × 312).

Serial number of rabbit	13		14		17		28		52	
Average value of long diameter	99	87	75	83	90	95	98	87	80	90
Average value of short diameter	99	92	75	85	83	90	99	85	90	95
Average value of the two diameter	99	89	75	84	86	92	98	86	85	92
Average of averages	96									

remarkably small value; MUELLER and CARLTON ('95) report the diameter as 103 μ, and PETER ('07) as 124 μ, in the adult cat; ARATAKI ('26) reports that the diameters of the glomeruli range in the male from 62 μ at birth to 124 μ at 500 days of age in the albino rat, thus showing an increase of twofold; the average diameter of the glomeruli in the human kidney is shown by SCHAEFER ('12) as being from 150 μ to 200 μ; by SCHWEIGGER-SEIDEL ('65) as being 200 μ, by ECKHART ('88) as being 85 μ at birth, and at maturity as being 196 μ in the female and 214 μ in the male in man; while it is given by KULZ ('99) as being 118 μ at birth, and 237 μ at maturity. According

to BRODIE and MACKENZIE ('14) it is 94 μ at rest and 100 μ during diuresis.

As to the number of the glomeruli in a definite area of 4.3 sq.mm., it is 32 on the average as shown in Table IV, and we find, by comparing our data with those (28) obtained by OKABE under the same conditions from his rabbits, that our rabbits had a slightly larger number in the glomeruli.

(B) Rabbit in which the Left Ureter was Ligated.

1. Histological Alterations in Various Stages of Hydronephrosis.

I. 4 days after the operation (No. 44).

The affected organ was a little larger than the organ of the other side, and its weight showed an increase of 41.6% over the normal, and 28.3% over the sister organ. In this period the dilatation of the pelvis was not yet so remarkable and its content measured only 0.5 cc. The cut surface of the affected organ was in general of a darkreddish colour.

In the portion near the hilum the renal pelvis dilated relatively strongly, and its compression led to circumscribed loss of the parenchym there. The basal portion of the renal pyramid next to the hilum also seemed to be compressed. Owing to the dilatation of the lumens in the uriniferous tubular system, especially in the collecting tubules, the distal convoluted portions and HENLE's loops were observed to have a reticular appearance of slight degree. In the lumens of the tubules in the outer zone of the medulla, various cylinders were proved. The glomeruli did not yet present any remarkable alteration, while BOWMAN's capsule dilated a little, but had no bloody content. In the loops of the capillary vessels of the glomerulus, blood was still abundantly proved. Most of the lumens of the proximal convoluted portion were dilated slightly, and their epithelia were compressed, but in the medullar portion, which adjoins to the dilated pelvis directly, we can observe sometimes a feature of so-called collapse.

II. From the 5th day to the 10th day.
(Nos. 32, 31, 7, 25, 51, 47).

The affected side showed a gradual increase in its weight and size against the sound sister organ, maintaining its original renal form. The stagnant fluid in the renal pelvis was not yet so abundant, but had a tendency to increase gradually, amounting to 0.8–3.5 cc.

In this period the weight of the parenchym of the affected organ considerably increased and was heavier than that of the standard, showing an increase of 60.7–175.0%. In this case, the earliest and greatest histological alteration occurred in the portion lying near to the hilum, due to the compression caused by the dilatation of the renal pelvis, while in the pyramid alteration was relatively slight.

With the increase in the weight of the parenchym, serous-infiltration of the interstitial tissue and dilatation of the lumens of the uriniferous tubules were brought about, thus leading to a reticular, or spongy appearance here and there. The cortical and medullary portions could still be distinguished from each other by means of the vasa arciformia, which were still well filled with blood, but thickening of their walls was not yet observed.

The glomerulus was not yet disturbed in its arrangement and its form. BOWMAN's capsule dilated slightly and sporadically, but neither abnormal content nor hemorrhage was observed therein. The loops of the capillary vessel of the glomerulus were still rich in blood. Their size was not yet reduced in dimension and showed a diameter of 90–95 μ on an average.

In this period the dilatation of the lumen of the uriniferious tubules came into sight in the total tubular system, and though it was especially remarkable in the collecting tubules, the distal convoluted portions, and the ascending limb of HENLE's loop, it was incomplete and slight in the proximal convoluted portion. Above all, in the tubules lying near the hilum, the dilatation of the lumens was there greatest, showing a relatively coarsely spongy structure, containing homogeneous masses; but such a content was found more abundant toward the distal part of the tubules. As to the distribution of blood, it was irregular and poor in general in the cortical portion, while in the middle zone of the medullary portion congestion of the capillary vessels was striking,

and in the pyramid, in which were arranged the collecting tubules with their enlarged lumens, there was a stasis of blood in the interstitia.

III. From the 11th to the 27th day.
(Nos. 5, 50, 10, 19, 33).

The increase in the weigt and size of the affected kidney was more striking than in the preceding examples. The affected kidney began to lose its original form and to increase in its thickness, thus forming a round sack.

In the last example, when 27 days elapsed after the operation, the organ showed slight lobation.

The weight of the remaining parenchym showed a gradual increase of 114.2-221.5%, and in one case on the 14th day after the operation, it increased by 221.5%, namely 3 times the normal weight, showing the maximum. Afterwards it decreased gradually, but still maintained an increase of 65.8-145.6%. In this series of experiments the stagnant fluid in the pelvis increased more than in the preceding cases (5-10 days), showing a tendency toward further increase and showing a content of 2.5-12.0 cc. Thus the dilatation of the pelvis and flattening of the pyramid were increased. In the renal parenchym, a relatively thick portion could be distinguished from a thin portion. The former was seen in the pyramidal portion, but the latter lay near the hilum. The cortical portion could be distinguished easily from the medullary one by the vasa arciformia, which were still filled with blood. In this period the dilatation of the uriniferious tubules was in general very remarkable, and their course was much disturbed and sometimes undulated.

Sometimes strong desquamation of the epithelium and degenerative alteration in the parenchym were not evenly distributed, thus presenting to the naked eye a spongy appearance in the stained preparation. From this fact it seems reasonable to suppose how striking was the infiltration of serous fluid in the interstitium and the stagnation of renal fluid in the tubules. The dilatation of the collecting tubules was not yet remarkable and their epithelia were still well maintained in the pyramid, containing homogeneous cylinders.

The proximal convoluted portion shows no longer a normal appearance, owing to collapse. The nuclei massed together exhibit moniliform

arrangement of the cell-bodies. Proliferation of the connective tissue was also here observed.

The renal corpuscles were reduced slightly in number and in diameter, showing 85 μ on an average, but their hyaline alteration was not yet seen. The filling of the capillary loops of the glomeruli was not remarkable and the nuclei of their epithelia were generally stained deeply, and not a few nuclei were patched. In BOWMAN's capsule no blood-discharge was proved. With regard to the distribution of blood in the affected organ, it was in general very irregular and poor; in the outer zone of the medulla, especially in the inter-tubular space, in which the collecting tubules dilated reticularly, the content of blood was relatively great. The arteries were in general filled, but in the veins the reverse was true, while in the cortical portion the blood content was still poorer.

IV. From the 30th to the 70th day.
(Nos. 46, 43, 4, and 28).

A distinctive character in this well advanced stage was the alteration in the parenchym, resp. fluctuation in weight of the renal parenchym, showing sometimes an increase of 13.6% or sometimes a decrease of 13.1–15.1%. In this period, however, the weight of the parenchym in the average value might be generally regarded as equal to that of the standard.

As to the general form, the affected side shows greater enlargement than that of the opposite side, but in general much more manifold in external outline than in the previous stage. In this stage the content in the pelvis was 10.0 cc. on the average. The histological findings of the kidney thus altered were different according to whether the portion were thick or thin, but notwithstanding this fact, there was a common character respectively. In the pyramidal portion the renal parenchym was the thickest, and the dilatation of the tubular lumens and desquamation of the epithelial cells of the uriniferous tubules had a manifold appearance, still presenting a spongy appearance of slight degree there. The thinnest portion also lay near the renal hilum, as was the case in previous series. The thinning of the renal parenchym was caused by the parenchymatous atrophy in both the cortex and medulla, but in the hydronephrotic atrophy most of

the medullar substance was first destroyed, after which the atrophy seemed to invade gradually the cortical substance.

Accordingly, the uriniferous tubules belonging to the medulla first fell into atrophy and degenerative alteration, and in the cortex there were not a few tubular lumens which reminded one of the collecting tubules, after degeneration of the proximal convoluted portion. The glomeruli reduced in number, and showed manifold irregularity. BOWMAN's capsule dilated greatly in general. The walls of the capsule were mostly thickened and extended over the neighbouring connective tissue. In such a thin portion there were still blood vessels in the interstitia, containing red-blood corpuscles. Capillary loops of the glomeruli were lobulated and poor in blood.

I may mention here one exceptionally remarkable example shown by an animal belonging to the 70 day experiment. It was found in this instance that the affected kidney showed the greatest enlargement on the whole course of the experimentation owing to the accumulation of the greatest amount of fluid within, and the organ was transformed into a large cystic sack containing as much as 30 cc. of clean serous fluid.

V. From the 75th to the 105th day.
(Nos. 23, 27, 40).

All the cases belonging to this stage showed the same general alterations as those of the previous stage, though the fluctuation in the weight and degenerative process was more distinctive. As to the weight of the affected kidney, the one showed an increase of 33.8%, and the other a decrease of 39.2%.

The volume of the affected organ was still a little greater than that of the opposite side, and its form was globular with several humped lobules. The quantity of the stagnant fluid in the pelvis renalis was 11.0–13.0 cc. The ligatured ureter dilated remarkably and presented a sausage-like appearance.

In this period the degenerative process in the parenchym was much advanced, and the thinnest portion lay near the renal hilum, as it were, but the thickest portion lay in the pyramidal portion. With regard to the other findings, there was no essential difference from the previous cases, but their degree was more advanced. Namely,

the degenerative process in the uriniferous tubular system in general was striking, proliferation of the connective tissue was also more distinctive, and the thickening of the walls of the blood vessels was remarkable.

VI. From the 120th to the 173rd day.
(Nos. 39, 24, 30, 36, 37, 35, 3 and 29)

In this stage the affected organ reduced in its size more markedly than in the previous stage, and lost its original form, transforming into a small cystic sack. In the opposite half (hemisphere) against the renal hilum, the structure was still discernible but the remaining half which corresponds to the renal pyramid became transparent and structureless. The weight of the parenchym was much less than the weight both of the standard and of the opposite side, and this reduction continues with time.

In a case in which 120 days elapsed after the operation, its reduction was as much as 70.5% ; namely about 1/3 of the standard weight. Therefore it is not difficult to suppose how actively the degenerative process in the parench m progresses. In this stage the stagnant fluid contained in the renal pelvis was 4.7 cc. in average. Disintegration of the parenchymatous element and proliferation of the connective tissue were more striking, and the cortical ray could not be observed. Even in the same affected kidney, the degree of degeneration differed according to the portion, as was found also in the previous stage.

In the thinner portion, the uriniferous tubules could not be recognized as such, while in the relatively thicker portion a spongy appearance of slight degree was still to be seen.

The glomerulus reduced more in number and BOWMAN's capsule dilated more, and the loop of the capillary vessel was depressed mostly against the distal pole, notwithstanding that it still contained a little blood. The capsule showed thickening and seemed to extend over the neighbouring connective tissue. In this period the proximal convoluted portion was no more observable, but only the collecting tubules with their dilated lumens were still discernible, even though they were very few in number.

VII. From the 200th to the 375th day. (Nos. 20, 6, and 2).

Cases in this stage stood almost in the same state as the preceding examples, but their degenerative process was more striking, and the size and weight of the affected organ reduced more remarkably. For instance, the affected organ lost 57.0–74.0%, maintaining only about 1/2–1/4 of its original weight. Thinning of parenchym due to degeneration increased more and more, and for the greater part of the organ it was transparent. In other words, proliferation of the interstitial connective tissue and degenerative process in the epithelium progressed by degrees. Both medullary and cortical layers became thinner, but could be distinguished from each other by the vasa arciformia.

In this period the stagnant fluid contained in the pelvis was 5.7 cc. in average. Even on the 375th day the relatively thick portion of the renal parenchym corresponded to the pyramidal portion, and the paper thin portion lay near the hilum. In the cortical portion, the other parenchymatous elements, excepting a few glomeruli, became completely degenerated, although a ring form structure with one layered epithelium which perhaps is a remnant of the collecting tubules is still rarely found.

The glomeruli were reduced remarkably in number and in diameter, showing 60 μ on the average. They were arranged sometimes in the outer layer of the narrowed cortex, sometimes a little inside of it, sometimes in groups, and sometimes scattered.

Transformation of BOWMAN's capsule and proliferation of the interstitial tissue were remarkable, but their hyaline alteration could not be observed. In the capillary-vessels in the glomeruli a little blood was still found. Degeneration in the uriniferous tubular system was so advanced that only a few canal lumens of the collecting tubules could be observed. In the basal portion of the pyramid there still remained a spongy structure, though much altered. The walls of the blood vessels of the vasa arciformia, resp. the vascular system, showed remarkable thickening and seemed to extend over the neighbouring tissue.

2. Changes in Urine after Ureteral Obstruction.

Urine was taken with a catheter in all those cases and analysed, but the collection of the diurnal urine could not be executed, to my regret, although it is necessary to know the diurnal amount of urine besides substances secreted for understanding of the renal function as well as general metabolism. For the collection of all the urine is a matter of great difficulty in small animals like the rabbit in experiments of long duration, as is well known to workers.

In the normal condition, the diurnal amount of urine was about 140 cc. (see Chapter III, A.), but it fluctuated within a considerably wide range after ureteral obstruction. Generally speaking, however, it reduced strikingly on the day of operation, but on the following days the decrease was not so remarkable as that on the day of the obstruction, and it increased gradually until it reached the normal amount, due probably to compensatory increase of function. The results of analysis are given in the following:

(In Tables VI (1), VI (2) and VI (3) are given the original protocoles, and in Table VI (4) summarises.)

pH The average value of the pH of the urine before operation was 7.15, but by the 10th day after operation it became acid in reaction (pH 6.95), which, however, shifted gradually into alkalinity, but in the last stage it became weakly acid again.

Specific gravity. Before operation, the specific gravity of the urine was 1.015 on the average, while after operation it increased gradually. We noticed that the value of the pH and that of the specific gravity showed a slight tendency to change in opposite directions, that is, a low value of the pH was associated with a higher specific gravity and vice versa.

The depression of the freezing point. This fluctuated in accordance with the specific gravity.

Total nitrogen. Before operation, the total nitrogen content was rather small, amounting to 903 mg. %. on the average. After operation, there was a general tendency toward gradual increase, though the content showed remarkable individual fluctuation as before, amounting to 1087 mg. % on the average. While it was about 520 mg. % (BERNET, '22), and 522 mg. % in the rabbit in milk feeding (SERIO),

Table VI. (1)

Findings in the urine before operation.

Days before operation	Serial No. of rabbit	pH	Spec. grav.	Depress. of freezing point	Total N	Urea N	Ammon. N	Creatinine	Water cont.	Dry subst.	Org. sub.	Inorg. sub.
					mg. in 100 cc.				g. in 100 cc.			
10	40	7.11	1.015	1.45	981	845	25	83	96.75	3.25	2.33	0..2
6	22	—	13	—	1096	722	38	92	97.90	2.10	1.40	0.70
	23	7.12	07	0.52	605	447	58	82	98.56	1.44	0.80	0.64
	37	6.10	13	0.82	552	468	21	87	98.49	1.51	0.98	0.50
	40	7.60	18	1.70	608	425	18	75	95.43	4.57	3.23	1.34
Average		6.94	15	0.95	715	501	33	83	97.59	2.41	1.60	0.79
2	19	—	1.018	—	1080	972	46	54	96.80	3.20	2.35	0.85
	20	—	07	—	576	497	—	60	97.60	2.40	2.00	0.40
	21	—	22	—	1200	1020		58	96.25	3.65	—	—
	22	—	14	—	1072	827	30	97	97.75	2.25	1.75	0.50
	23	8.25	11	0.56	766	602	21	100	98.42	1.58	0.95	0.63
	25	6.70	09	0.70	1312	1175	21	93	98.55	1.45	1.15	0.30
	26	8.79	10	0.55	1167	839	21	77	98.87	1.13	0.69	0.44
	27	7.80	09	0.78	1216	978	32	90	97.77	2.23	1.50	0.73
	28	8.95	10	0.57	636	563	17	80	98.46	1.54	0.95	0.59
	29	7.12	06	0.56	—	752	23	—	99.11	0.89	0.67	0.22
	30	7.08	14	0.70	1032	814	21	60	97.25	2.75	1.95	0.80
	31	7.43	13	0.92	820	677	23	80	98.00	2.00	1.55	0.45
	32	7.10	14	1.25	1280	902	18	92	97.10	2.90	2.20	0.70
	35	7.01	33	2.05	840	625	24	55	98.07	1.93	1.18	0.75
	36	6.75	05	0.35	—	—	20	—	99.35	0.65	0.34	0.31
	37	5.75	13	0.85	672	560	21	90	[illegible]	[illegible]	1.05	0.59
	38	6.93	14	0.88	834	692	22	80	98.06	1.94	1.34	0.60
	39	—	—	—	—	—	—	—	94.88	5.12	3.63	1.48
	40	7.29	24	2.15	—	—	13	—	—	—	—	—
Average		7.35	1.014	0.81	970	781	24	78	97.82	2.17	1.48	0.60
Just before	7	—	1.018	—	1310	1081	42	70	97.54	2.46	1.62	0.84
	19	—	18	—	1034	826	42	65	96.91	3.09	2.33	0.78
	20	—	07	—	1018	824	35	90	98.62	1.38	1.10	0.28
	22	—	14	—	1070	792	28	85	97.74	2.26	1.88	0.38
	23	7.38	18	1.03	929	774	23	55	97.53	2.47	1 78	0.69
	25	6.39	11	0.90	1214	1040	21	70	98.16	1.84	1.38	0.47
	26	8.31	21	1.35	1167	910	21	83	97.16	2.84	1.90	0.94
	28	6.54	09	0.60	770	593	24	40	98.42	1.58	1.01	0.57
	29	7.31	17	1.05	1053	819	23	90	97.27	2.73	2.01	0.72
	30	7.07	11	0.51	1030	852	23	93	97.24	2.96	2.50	0.46
	31	7.51	12	0.91	823	696	22	78	98.17	1.83	1.42	0.41
	32	7.05	15	1.30	1232	998	20	97	97.38	2.62	1.90	0.72
Average		7.20	1.014	0.87	1054	830	25	78	97.72	2.29	1.68	0.59
Total average		7.15	1.015	1.02	903	767	27	80	97.47	2.53	1.77	0.72

TABLE VI. (2)

Findings in the urine after operation.

Days after operation	Serial No. of rabbit	pH	Spec. grav.	Depress. of freezing point	Total N	Urea N	Ammon. N	Water cont.	Dry subst.	Org. sub.	Inorg. sub.
					mg. in 100 cc.			g. in 100 cc.			
2	7	—	1.024	—	1210	1017	33	96.45	3.55	2.65	0.89
	20	—	08	—	968	795	34	98.62	1.38	1.11	0.27
	23	6.60	19	1.10	1010	791	21	97.70	2.30	1.07	0.77
	27	7.40	08	0.60	890	758	44	98.20	1.80	1.10	0.70
	28	7.05	09	0.60	750	594	24	97.53	2.47	1.87	0.60
	29	6.75	17	1.30	1232	953	33	96.80	3.20	2.50	0.70
	30	7.50	15	0.90	1216	990	24	97.20	2.80	2.30	0.50
	35	6.15	16	1.25	1064	893	32	67.76	2.24	1.48	0.76
	37	7.70	13	1.10	1085	864	19	97.43	2.57	1.80	0.77
	40	6.45	17	1.20	1120	952	26	95.75	4.25	3.05	1.20
Average		6.95	15	1.00	1034	961	29	97.34	2.66	1.89	0.71
6	20	—	18	—	942	762	32	98.60	1.40	1.11	0.29
	23	5.90	18	1.20	1130	881	21	97.92	2.08	1.28	0.80
	28	7.70	09	1.05	825	691	24	96.40	3.60	3.13	0.47
	29	6.70	18	1.40	1290	930	35	96.65	3.35	2.70	0.65
	30	8.30	22	1.50	1533	1289	24	97.10	2.90	1.90	1.00
	40	6.10	14	0.56	959	770	27	98.10	1.90	1.50	0.40
Average		6.94	16	1.55	1113	895	27	97.46	2.56	1.94	0.61
10	20	—	18	—	980	723	30	98.60	1.40	1.15	0.25
	23	5.90	18	1.20	1120	987	20	97.95	2.05	1.35	0.70
	28	7.40	11	0.80	970	698	22	96.35	3.65	3.15	0.50
	29	7.03	19	1.40	1112	865	32	96.70	3.30	2.60	0.70
	30	8.00	22	1.50	1216	952	23	97.43	2.57	1.57	1.00
	40	6.60	14	0.40	1037	850	32	97.30	2.70	2.00	0.72
Average		6.99	17	1.06	1072	846	26	97.39	2.61	1.97	0.64
15	20	—	19	—	893	700	28	98.60	1.40	1.20	0.20
	23	5.90	18	1.20	1160	876	18	97.95	2.05	1.40	0.65
	28	7.10	14	1.00	990	810	21	96.35	3.65	3.12	0.57
	29	7.50	19	1.40	1210	957	27	96.90	3.10	2.40	0.70
	30	7.00	20	1.15	1230	998	20	97.91	2.09	1.20	0.89
	40	7.60	11	1.00	1051	863	39	95.40	4.00	3.50	1.10
Average		7.02	17	1.15	1086	867	26	97.18	2.83	2.14	0.68
25	20	7.10	10	0.70	1099	858	—	98.40	1.60	1.03	0.57
	23	5.95	18	1.12	985	817	14	97.97	2.03	1.47	0.56
	24	8.23	16	0.95	939	735	42	98.37	1.63	0.87	0.76
	28	6.50	21	1.55	1342	1095	19	96.27	3.73	3.03	0.69
	29	8.25	20	1.45	1366	985	18	97.15	2.85	2.10	0.75
	30	6.45	15	0.85	1073	873	18	98.15	1.85	2.10	0.76
Average		7.26	17	1.14	1117	894	21	97.71	2.30	1.61	0.66

TABLE VI. (3)

Findings in the urine after operation.

Days after operation	Serial No. of rabbit	pH	Spec. grav.	Depress. of freezing point	Total N	Urea N	Ammon. N	Water cont.	Dry sub.	Org. sub.	Inorg. sub.
					mg. in 100 cc.			g. in 100 cc.			
35	20	7.70	1.013	0.80	920	705	24	98.50	1.50	1.10	0.40
	23	6.38	14	0.85	765	632	18	98.40	1.60	1.13	0.47
	24	7.30	13	0.80	925	576	13	98.32	1.68	1.20	0.48
	28	6.20	23	1.20	1288	1055	17	96.40	3.06	3.01	0.59
	29	8.20	17	1.15	1165	911	18	97.12	2.88	2.28	0.60
	30	6.50	10	0.65	1225	994	17	98.00	2.00	1.50	0.50
Average		7.05	15	0.91	1048	812	18	97.79	2.21	1.68	0.53
45	20	8.10	10	0.70	700	523	24	98.55	1.45	1.00	0.40
	23	6.84	10	0.55	743	605	24	98.81	1.19	0.72	0.47
	24	7.20	10	0.57	1010	925	18	97.34	2.66	2.28	0.28
	28	6.00	24	1.90	1259	985	17	96.51	3.49	3.00	0.49
	29	8.15	13	0.95	750	578	17	97.07	2.93	2.46	0.47
Average		7.24	13	0.93	892	723	20	97.66	2.34	1.90	0.44
55	6	—	13	—	1110	841	30	98.48	1.52	1.00	0.52
	23	7.20	14	0.95	898	764	25	98.30	1.70	1.15	0.55
	24	7.80	08	0.55	1170	830	18	95.70	4.30	3.93	0.37
	28	6.50	24	1.70	1280	1091	22	96.90	3.10	2.67	0.43
	29	7.99	16	1.10	1025	770	22	96.98	3.02	2.38	0.63
Average		7.37	15	1.08	1096	859	23	97·26	2.73	2.23	0.51
65	6	—	13	—	1002	813	35	99.00	0.00	0.70	0.30
	23	7.57	17	1.37	1068	858	26	97.80	2.20	1.50	0.70
	20	6.85	14	1.30	1020	705	18	96.60	3.40	2.90	0.50
	28	7.20	23	1.50	1248	1027	29	96.25	3.75	2.80	0.95
	29	7.70	19	1.30	1112	850	25	96.90	3.10	2.32	0.78
Average		7.33	17	1.37	1090	850	26	97.51	2.49	1.94	0.54
75	6	—	14	—	1088	802	37	98.90	1.10	0.75	0.35
	20	6.85	11	0.90	1100	810	—	98.15	1.85	1.50	0.35
	33	7.90	20	1.80	1240	1052	27	97.25	2.75	1.90	0.81
	28	8.30	23	1.15	1201	893	39	97.87	2.13	1.67	0.44
Average		7.68	20	0.74	1157	912	34	98.04	1.96	1.48	0.48
85	6	—	14	—	1176	915	39	98.75	1.25	0.83	0.42
95	6	—	15	—	1272	946	41	98.60	1.40	0.90	0.50
105	6	—	15	—	1048	799	42	98.51	1.49	0.90	0.59
115	6	—	14	—	1216	951	42	98.53	1.47	0.88	0.60
125	6	—	13	—	980	712	41	98.56	1.44	0.80	0.64
135	6	7.61	12	0.90	875	705	41	98.61	1.39	0.74	0.65
145	6	7.17	18	1.05	1064	803	41	98.21	1.79	1.23	0.56
165	6	7.30	13	0.90	944	715	21	98.30	1.70	1.20	0.58
185	6	6.30	14	1.20	1248	1081	33	97.00	3.00	2.20	0.70
205	6	6.00	12	1.00	1234	1013	54	97.30	2.70	2.07	0.60
Total average		7.15	1.015	1.07	1087	858	32	97.88	2.11	1.53	0.58

TABL. VI. (4)
(Summary of Tables VI (1), VI (2) and VI (3))

Days		pH	Spec. gravity	Depress. of freez. point	Total-N	Urea-N	NH_3-N	Creati-nine	Water content	Dry sub.	Org. sub.	Inorg. sub.
					mg. in per 100 cc.				g. in per 100 cc.			
before operat.	10	7.11	1.015	1.45	981	845	25	83	96.75	3.25	2.33	0.92
	6	6.94	15	0.95	715	501	33	83	97.59	2.41	1.60	0.79
	2	7.35	14	0.81	970	781	24	78	97.82	2.17	1.48	0.60
just before		7.20	14	0.87	1054	850	25	78	97.72	2.29	1.68	0.59
Total aver.		7.15	1.015	1.02	903	767	27	80	97.47	2.53	1.77	0.72
after operat.	2	6.95	15	1.00	1090	861	29	..	97.34	2.66	1.86	0.71
	6	6.94	16	1.55	1113	895	27	..	97.46	2.56	1.94	0.61
	10	6.99	17	1.06	1072	846	26	..	97.39	2.61	1.97	0.64
	15	7.02	17	1.15	1089	867	26	..	97.18	2.82	2.14	0.68
	25	7.25	17	1.14	1117	894	21	..	97.71	2.30	1.61	0.66
	35	7.05	15	0.91	1048	812	18	..	97.79	2.21	1.68	0.53
	45	7.26	13	0.93	892	723	20	..	97.67	2.34	1.90	0.44
	55	7.37	15	1.08	1096	853	23	..	97.26	2.74	2.23	0.51
	65	7.33	17	1.37	1090	850	26	..	97.51	2.49	1.94	0.54
	75	7.68	20	0.74	1157	912	34	..	98.04	1.96	1.48	0.48
	85		14	..	1176	915	39	..	98.75	1.25	0.80	0.42
	95	..	15	..	1272	946	41	.	98.60	1.40	0.90	0.50
	105	..	15	..	1215	951	42	..	98.51	1.49	0.90	0.57
	115		14	.	1048	799	42	.	98.53	1.47	0.88	0.60
	125	..	13	.	980	712	41	.	98.56	1.44	0.80	0.62
	135	7.61	12	0.90	875	705	41	..	98.61	1.39	0.74	0.65
	145	7.17	18	1.05	1064	803	41	..	98.21	1.79	1.23	0.56
	165	7.30	13	0.90	944	715	21	..	98.30	1.70	1.20	0.58
	185	7.30	13	1.20	1248	1081	33	..	97.00	3.00	2.20	0.70
	205	6.00	12	1.00	1224	1013	54	..	97.30	2.70	2.07	0.60
Total aver.		7.15	15	1.07	1087	858	32	..	97.88	2.11	1.53	0.58

and it was about 1120 mg. % in normal human urine (OPPENHEIM).

Urea nitrogen. The content of urea N was 767 mg. % on the average before operation and it corresponds to 84.9% of the total N. The content of urea N was 858 mg. % after operation and it corresponds to 78.8% of the total N. It corresponded to 85% to the total N in human urine (LANDOIS), it corresponded to 87.5% in human urine (OPPENHEIM); 78–88% in diet rich in protein, while 60% in diet poor in protein (FOLIN), it was 72% in starvation (CATHCART, '07) and about the same in a new-born infant (SJOEQVIST, '07). It

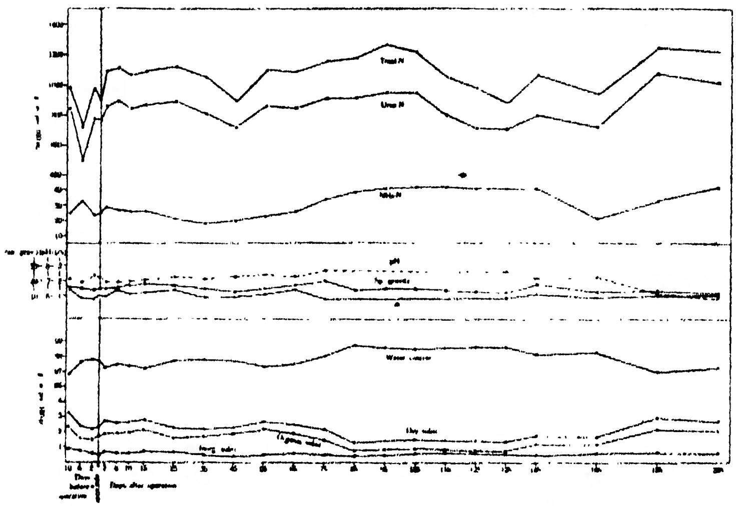

Fig. 2. Showing findings in the urine before and after the operation. (constructed from Table VI (4).)

corresponded to 75% in dogs, to 98% in protein feeding and 86% in carbohydrate-feeding (SCHOENDORFF, '07).

Ammonia N. Before operation it was 27 mg. %, while it was 32 mg. % after operation, on the average.

Water content. Before operation it was 97.5% on the average. After operation it fluctuated and showed a tendency toward decreasing till about the 35th day, showing a gradual increase in its amount up to the 135th day. The content of dry substance is inversely related, of course, to the water content. Till about the 75th day after operation, the content of dry substance increased markedly, afterwards it showed some decrease till about the 135th day, thereafter showing a tendency to increase.

The content of organic substance fluctuated almost in parallel with the dry substance, and the latter seems to consist mostly of the organic substance. The inorganic substance remains almost constant throughout the experiment.

3. Changes in the Weight and Chemical Components of the Kidney after Ureteral Obstruction.

Changes in the weight (Table VII and Fig. 3)

TABLE VII. (1)

Biochemical findings in the renal parenchym after operation.

Stadium	Serial Number of rabbit	Body weight (g.)	Days after operation	W Weight of kidney calculated from normal ratio, kidney-w. / body-w. (g.)	W′ Weight of kidney (g.) Right	W′ Weight of kidney (g.) Left	Pelvic fluid (cc.)	Weight of parenchym l. obstr. kidney (g.)	Increase of weight of kidney (W′–W) (g.) Right	Increase of weight of kidney (W′–W) (g.) Left	Increase of weight of kidney (%) Right	Increase of weight of kidney (%) Left
I	44	1770	4	6.0	7.7	8.5	..	80	1.7	2.5	28.3	41.6
	32	1180	5	4.0	6.8	12.0	0.8	11.0	2.8	8.0	70.0	200.0
	31	1305	6	4.4	6.8	9.0	..	9.0	2.4	5.0	54.6	113.0
	7	1640	7	5.6	6.1	11.3	2.0	9.0	0.5	5.7	8.9	101.7
	25	1430	8	4.9	5.9	15.0	3.5	10.6	1.0	10.1	20.4	206.2
	51	1360	9	4.6	7.8	10.5	0.5	9.7	3.2	5.9	69.6	128.2
	47	1780	10	6.1	9.0	14.0	1.2	12.5	2.9	9.9	47.6	162.3
	5	1435	11	4.9	9.4	15.0	3.6	11.0	4.5	10.1	91.8	206.2
	50	1020	13	3.5	7.0	10.5	2.5	7.5	3.5	7.0	100.0	200.0
	10	1245	14	4.2	6.5	19.0	4.5	13.5	2.3	14.8	54.7	351.6
	19	1195	17	4.1	6.0	11.7	4.0	6.8	1.9	7.6	46.3	185.6
	33	1665	27	5.7	10.0	35.0	12.0	14.0	4.3	29.3	75.4	510.0
Average		1418		4.8	7.4	14.2	3.5	12.1	4.0	9.7	55.6	200.5
II	46	1940	30	6.6	8.3	8.5	0.5	7.5	1.6	1.9	24.2	28.7
	43	1550	40	5.3	6.5	9.2	4.0	4.5	1.2	3.9	22.7	73.6
	4	1513	45	5.1	7.5	11.4	5.5	6.6	2.4	6.3	47.0	123.5
	28	2020	70	6.9	8.5	39.0	30.0	6.0	1.6	29.1	23.7	421.8
	23	2095	75	7.1	8.2	23.0	13.0	9.5	1.1	15.9	17.0	245.6
	27	2170	85	7.4	14.3	9.0	4.0	4.5	6.9	11.6	87.0	21.6
	40	2280	105	7.8	12.0	21.1	11.0	8.4	4.2	14.3	53.8	183.3
Average		1938		6.6	9.3	17.3	11.2	6.7	2.7	11.9	39.3	157.0
III	39	2000	120	6.8	7.0	5.1	3.0	2.0	0.2	-1.7	2.9	-25.0
	24	1940	124	6.6	11.0	10.0	6.0	3.0	4.4	3.4	69.6	51.4
	30	2060	127	6.8	8.8	9.6	2.5	6.4	2.0	2.8	29.4	41.2
	36	2550	133	8.6	9.0	8.6	3.6	4.3	0.4	-0.6	4.7	- 6.9
	37	2220	138	7.5	7.0	5.5	..	5.0	-0.5	-2.0	-6.7	-26.7
	35	2150	140	7.3	9.0	7.5	4.5	2.7	1.7	0.2	23.3	2.7
	34	2860	148	6.2	6.9	13.1	4.5	8.7	0.7	6.9	11.2	111.3
	3	1860	163	8.0	10.0	15.0	10.0	5.0	2.4	7.0	30.0	87.5
	29	1750	173	6.0	10.4	3.7	..	3.7	4.4	-2.3	73.3	-38.3
	20	2060	200	7.0	8.5	10.7	7.3	3.0	1.5	3.7	21.4	52.8
	6	1590	237	5.4	7.9	4.1	2.7	1.4	2.5	-1.3	46.3	-24.1
	2	1630	375	5.5	9.7	10.0	7.0	2.3	4.2	4.5	76.4	81.3
Average		2014		6.8	8.8	8.5	5.1	3.9	2.0	1.7	31.6	25.5
Average of averages		1766		6.0	8.4	12.7	6.1	7.0	2.9	7.1	42.6	128.0

Table VII. (2)

Biochemical findings in the renal parenchym after operation.

Stadium	Serial No. of rabbit	Increase in weight of parenchym of left kidney		Water content of parenchym		Dry subst. ,,		Org. subst. ,,		Inorg. sub. ,,		Total nitrogen of fresh material		Total nitrogen of dry subst.	
		(g)	(%)	(%)		(%)		(%)		(%)		(%)		(%)	
				R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.
I	44	2.0	33.3	79.68	77.53	20.32	22.47	19.05	20.39	1.27	2.08	2.84	2.93	15.70	13.06
	32	7.0	175.0	76.80	80.38	23.20	19.62	21.61	18.30	1.59	2.32	2.93	2.51	12.65	12.80
	31	4 6	104.6	77.89	80.76	22.11	19.24	19.11	17.84	1.91	1.40	3.01	2.66	13.55	13.80
	7	3.4	60.7	77.74	80.24	22.26	19.76	20.90	18.50	1.32	1.27	3.44	2.47	15.44	12.48
	25	5.7	116.3	77.41	.	22.59	..	21.17	..	1.42	..	2.82	2.31	12.47	..
	51	5.1	110.9	80.35	80.68	19.65	19.32	17.60	17.62	2.05	1.70	2.45	2.18	12.46	11.27
	47	6.4	104.9	79.47	81.49	20.53	18.53	19.19	17.24	1.78	1.29	2.45	1.93	11.93	9.86
	5	6.1	124.5	77.53	79.09	22.47	20.21	21.40	19.40	1.03	1.47	2.84	2.58	12.65	12.78
	50	4.0	114.2	77.56	80.83	22.44	19.17	20.88	17.74	1.56	1.43	2.49	2.26	11.07	11.79
	10	9.3	221.5	77.23	80.19	22.77	19.81	.	..	..	..	3.08	2.99	13.52	15.08
	19	2.7	65.8	76.41	77.90	23.59	22.10	22.62	20.74	1.33	1.36	3.22	3.20	13.43	14.50
	33	8.3	145.6	78.48	80.79	21.52	19.21	20.39	18.01	1.13	1.20	3.01	2.53	13.97	13.16
Average		5.4	114.7	78.04	79.99	21.95	20.00	20.35	18.58	1.49	1.45	2.88	2.55	13.23	12.78
II	46	0.9	13.6	74.83	78.06	25.17	21.94	23.44	19.99	1.73	1.95	2.35	2.46	9.33	11.20
	43	-0.8	15.1	78.14	82.52	21.83	17.48	20.34	16.00	1.49	1.48	2.73	2.21	12 50	13.83
	4	1.5	29.4	74.17	80.60	25.83	19.40	24.39	17.98	1.44	1.42	2.82	2.53	10.91	13.03
	28	-0.9	-13.0	76.47	77.14	23.53	22.86	22.02	21.59	1.51	1.27	2.59	2.72	11.02	11.89
	23	2.4	33.8	74.92	77.05	25.08	22.95	23.73	21.96	1.35	0.99	3.05	2.66	12.16	91.57
	27	-2.9	-39.2	79.84	76.28	20.16	23.72	19.03	22.11	1.13	1.61	2.59	2.28	12.86	9.60
	40	0.6	7.7	79.01	79.33	20.99	20.67	19.03	19.48	1.21	1.19	2.30	2.06	10.94	9.93
Average		0.1	2.5	76.77	78.71	23.23	21.29	21.71	19.87	1.41	1.41	2.63	2.42	11.39	11.58
III	39	-4.8	-70.5	74.95	74.13	25.05	25.87	24.69	24.13	1.41	1.74	1.94	2.72	7.73	10.51
	24	-3.6	-54.5	77.67	78.82	22.33	21.18	21.12	20.26	1.21	0.92	1.85	2.50	8.26	11.02
	30	-0.4	- 5.9	79.03	81.85	20.97	18.15	19.86	17.10	1.11	1.05	2.49	2.30	11.89	12.69
	36	-4.3	-50.0	77.86	79.62	22.14	20.38	20.84	19.49	1.30	0.89	2.14	2.40	9.67	11.79
	37	-2.5	-33.3	75.69	71.80	24.31	28.20	23.19	26.62	1.12	1.58	2.70	2.82	11.11	9.99
	35	-4.6	-63.0	75.18	74.47	24.82	25.54	23.32	24.15	1.50	1.39	2.55	2.14	10.26	8.39
	34	-2.5	-40.3	74.69	78.97	25.31	21.03	..	..	..	..	2.69	2.47	10.63	11.72
	3	3.0	-43 5	78.93	80.98	21.07	19.42	19.86	18.48	1.21	0.96	2.78	2.49	13.20	12.83
	29	-2.3	-38.3	80.01	78.20	19.99	21.80	18.61	20.12	1.38	1.68	1.94	2.22	9.68	10.20
	20	-4.0	-57 1	75.76	74.32	24.24	25.68	23.87	24.47	1.37	1.21	2.77	2.51	11.44	9.78
	6	-4.0	-74.1	78.49	81.15	21.51	18.85	19.37	17.81	2.14	1.04	2.93	2.98	13.64	15.80
	2	-3.2	-58.2	79.60	81.02	20.40	18.98	19.11	17.86	1.29	1.12	2.88	2.46	14.11	12.94
Average		-3.3	-48.3	77.32	77.91	22.68	22.09	21.25	20.95	1.36	1.25	2.47	2.50	10.97	11.47
Aver. of averages		0.8	26.3	77.48	78.74	22.52	21.26	21.02	19.83	1.42	1.35	2.67	2.50	11.94	11.59

TABLE VII. (3)

Biochemical findings in the renal parenchym after operation.

Stadium	Serial No. of rabbit	Total N of dry subst. excluding fatty subst. (%)		NaCl of fresh kidney (%)		NaCl of dry subst. (%)		NaCl of dry subst. excluding fatty subst. (%)		Fatty substances of fresh kidney (%)		Fatty substances of dry subst. (%)	
		Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
	44	22.79	19.45	0.13	0.22	0.62	0.99	1.01	1.49	7.84	7.39	38.6	32.9
	32	17.29	18.26	0.18	0.22	0.78	1.05	1.10	1.57	6.22	5.87	26.3	29.9
	31	17.84	15.98	0.27	0.13	1.19	0.70	1.51	1.55	5.32	2.63	24.1	13.7
	7	22.34	18.85	0.26	0.27	1.15	1.34	1.69	2.00	6.87	6.68	30.9	33.3
	25	16.75	.	0.25	0.22	1.12	..	1.50	..	5.77	3.86	25.53	..
	51	15.03	15.12	0.11	0.11	0.55	0.58	0.66	0.78	3.36	4.91	17.1	25.4
I													
	47	18.68	15.40	0.17	0.30	0.84	1.59	1.32	2.57	7.43	7.02	36.2	38.3
	5	19.82	21.28	0.39	0.34	1.73	1.68	2.71	2.79	8.12	8.07	36.1	39.9
	50	17.04	17.26	0.22	0.23	0.98	1.21	1.51	1.77	7.86	6.11	35.0	31.9
	10	18.94	21.87	0.31	0.31	1.37	1.53	1.92	2.22	6.52	6.15	28.6	31.1
	19	18.31	19.12	0.25	0.30	1.41	1.81	1.41	1.81	6.40	5.35	26.7	24.2
	33	20.04	17.56	0.30	0.36	1.41	1.29	2.02	1.72	6.52	4.81	30.3	25.1
Average		18.74	18.19	0.24	0.25	1.06	1.21	1.52	1.84	6.53	5.73	29.6	29.6
	46	14.64	14.47		0.34	..	1.62	..	1.96	9.13	4.96	..	22.6
	43	18.12	18.50	0.19	0.27	0.87	1.29	1.26	1.67	6.78	4.03	31.1	23.1
	4	13.73	17.70	0.32	0.27	1.23	1.37	1.55	1.86	5.32	5.13	20.6	26.4
II	28	15.48	16.21	0.19	0.31	0.79	1.36	1.11	1.70	6.79	6.10	28.9	20.2
	23	17.13	13.05	0.32	0.22	1.26	1.69	1.77	2.11	7.27	2.60	28.9	20.0
	27	19.34	13.56	0.11	0.27	0.54	1.14	0.81	1.61	6.76	6.93	33.5	29.2
	40	15.37	13.12	0.21	0.22	1.00	1.12	1.03	1.48	6.08	5.03	28.9	24.3
Average		16.26	15.23	0.22	0.26	0.95	1.35	1.26	1.77	6.88	4.97	28.6	23.7
	39	12.02	.	0.47	..	1.85	..	..	..	8.95	..	..	..
	24	11.97	19.23	0.17	0.35	0.75	1.67	1.08	2.71	6.92	8.17	31.0	38.6
	30	16.18	17.40	0.21	0.22	1.01	1.21	1.37	1.65	5.56	4.91	26.5	27.1
	36	13.25	17.51	0.23	0.26	1.03	1.10	1.41	1.63	5.97	6.66	26.9	32.7
	37	16.14	12.81	0.25	0.27	1.01	0.96	1.47	1.23	7.58	6.22	31.2	22.1
	35	12.84	10.56	0.31	0.48	1.26	1.86	1.56	2.34	4.98	5.28	20.0	20.7
III													
	34	15.75	18.17	0.20	0.32	0.78	1.54	1.15	2.38	8.22	7.46	32.3	35.5
	3	19.19	15.97	0.34	0.35	1.61	2.72	2.34	3.34	6.68	3.83	31.2	19.7
	29	15.13	14.13	0.30	0.23	1.50	1.05	2.34	1.45	7.21	6.07	36.1	27.8
	20	17.06	14.48	..	..	..	..	..	..	7.99	8.35	32.9	32.5
	6	18.25	19.43	0.18	0.34	0.83	1.43	1.11	1.76	5.43	3.52	25.3	18.7
	2	18.55	14.49	0.11	0.14	0.54	0.74	0.81	0.71	4.85	1.63	23.8	8.6
Average		15.53	16.02	0.26	0.31	1.11	1.43	1.46	1.98	6.69	5.65	28.8	25.9
Aver. of averages		16.94	16.65	0.24	0.27	1.04	1.33	1.86	1.86	6.63	5.49	29.0	26.40

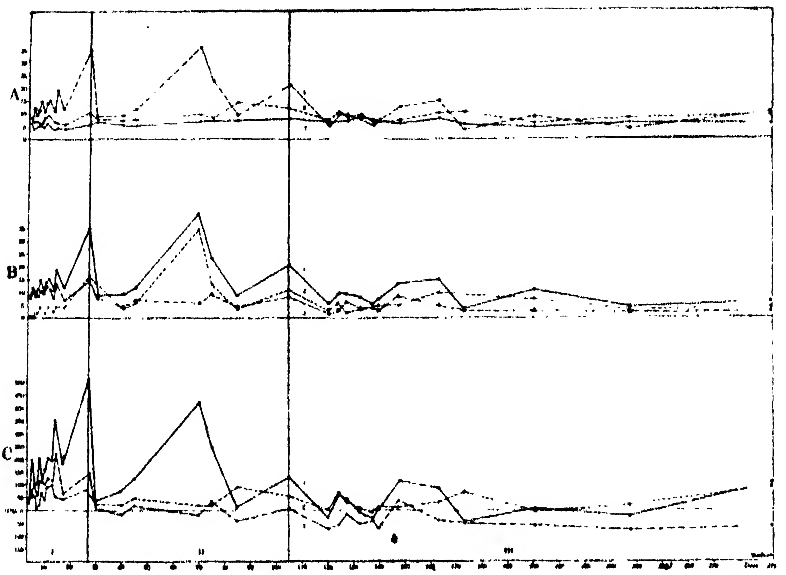

Fig. 3. Showing the relation among the weights of the left (obstructed) and right kidneys after operation. Constructed from Table VII.

A. Total weight of the kidneys.
Abscissa : days after operation.
Ordinate : the weight of the kidneys in grams.
1 : obstructed kidneys (left) including fluid in the pelvis.
2 : sister kidneys (right).
3 : normal kidneys.

B. 1 : obstructed kidneys including the pelvic fluid.
2 : amount of the pelvic fluid in cc.
3 : obstructed kidneys excluding the pelvic fluid.

C. Increased weight of both kidneys and the weight of the obstructed kidneys excluding the pelvic fluid.
Abscissa : the same as in A.
Ordinate : increase of weight in per cent.
1 : total weight of the obstructed kidneys.
2 : total weight of the sister kidneys.
3 : obstructed kidneys excluding the pelvic fluid.

The total weight and the volume of the obstructed kidney including the pelvic fluid increases in general slowly but gradually, while the weight of the renal parenchym excluding the pelvic fluid increase rather rapidly, though they show of course considerable individual fluctuation, and thus both reach their maximum, then decrease in their

weight slowly again.

On the other hand the weight and volume of the sister kidney increases also steadily and gradually to some extent owing to compensatory function.

Considering these changes, we can find some correlation among them and we may properly divide the whole course of the experiment into the following three stadiums.

The first stadium covers a period extending from the beginning to the 27th day, in which the weight of the parenchym of the obstructed kidney is greater than those of the sister, normal kidney and the pelvic fluid.

The second stadium covers a period extending from the 28th till the 105th day, in which the weight of the parenchym of the obstructed kidney is almost equal to that of the normal kidney. And the third stadium, the last period, in which the weight of the obstructed organ is less than that of the sister and normal kidney and also less than the weight of the pelvic fluid.

This division of the stages based on the anatomical and histological changes of the obstructed kidney also apply to the chemical findings as shown in chapter VI, 1.

The values in the components of the obstructed kidneys show in general a far more remarkable fluctuation than those of the sister and of the normal kidneys, as is shown in the above table.

Water content of the obstructed kidneys.

During the entire course of experiment the water content of the obstructed kidney fluctuated between 74.32% and 82.52%, while that of the sister kidneys fluctuated between 74.17% and 80.35%, and that of the normal kidney fluctuated between 74.46 and 79.16%. The total average in the water content of the obstructed kidney was 78.74%, contrasted with 77.48% in the sister and 77.43% in the normal kidneys, so the water content of the obstructed kidney showed an excess of 1.7% over the normal and also an excess of 1.6% over the sister kidney, while the hypertrophied sister organ was hardly altered from the normal with respect to its water content, showing an excess of only 0.1%, though it showed a slight excess (0.8%) in the first stadium. But this was much less than that of the obstructed organ,

showing a reduction of 2.6%.

In the first stadium the water content of the obstructed kidney was the greatest, and showed an excess of 3.3% over the normal and 3.2% over that of the sister kidney; in the second stadium it showed an excess of 1.7% over that of the normal and 1.6% over that of the sister kidney; and finally in the third stadium it was the least but still showed an excess of only 0.6% over that of the normal and 0.5% over that of the sister kidney.

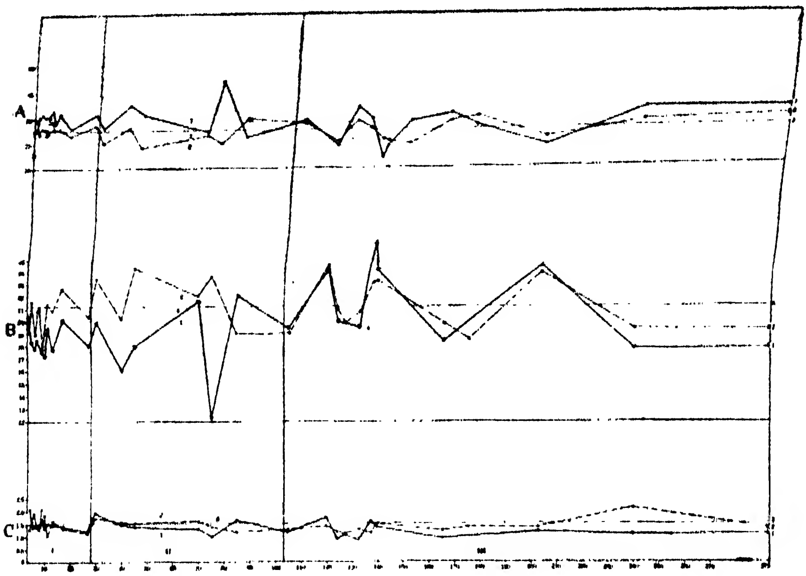

Fig. 4. Showing comparison of water content (A), organic (B), and inorganic substance (C) of both kidneys after operation. (Constructed from Table VII)

Abscissa : days after operation.

Ordinate : substance in per cent.

A. 1 : water content of the obstructed kidneys.
2 : water content of the sister kidneys.
3 : water content of the normal kidneys.

B. 1 : organic substance of the obstructed kidneys.
2 : organic substance of the sister kidneys.
3 : organic substance of the normal kidneys.

C. 1 : inorganic substance of the obstructed kidneys.
2 : inorganic substance of the sister kidneys.
3 : inorganic substance of the normal kidneys.

Organic substance in the obstructed kidney. (Table VII and Fig. 4, B)

The content of the organic substance was 19.83% in the obstructed kidney, 21.02% in the sister organ and 21.07% in the normal kidney on the total average, though they showed also somewhat remarkable fluctuation in individual observation as was the case in regard to the water content. The content of the organic substance in the parenchym of the obstructed kidneys showed a decrease of 5.8% below that of the normal and 5.7% below that of the hypertrophied sister organs. In the three stadiums mentioned, we find the following relations with respect to the content of the organic substance: in the first stadium a decrease of 11.8% below the normal and 11.6% below the sister organ; in the second stadium a decrease of 5.7% below the normal and 5.5% below the sister organ; and in the third stadium a decrease of only 0.6% below the normal and only 0.3% below the sister organ. In the total average the sister kidney shows a decrease of only 0.3% below the normal. If, however, the three stadiums are considered separately, we notice that there is a somewhat greater difference between the two in the earlier period. But, on the whole, the organ, which shows a compensatory hypertrophy, does not show any remarkable changes in the amount of the organic substance.

Inorganic substance (Table VII and Fig. 4, C).

The content of the inorganic substance of the obstructed kidney was 1.35%, that of the hypertrophied sister organ 1.42%, and that of the normal 1.51%, on the total average. Therefore, in the obstructed organ it showed a decrease of 10.6% below the normal and a decrease of 4.9% below the sister organ. If the average value in the first stadium is compared with the entire averages taken from the sister and normal kidney, the obstructed organ shows a decrease of 4% below the normal, but it shows an increase of 2.1% over the sister organ.

In the second stadium it shows a decrease of 6.6% below the normal and a decrease of only 0.7% below the sister organ. In the third stadium it shows a decrease of 18.5% below the normal and 13.4% below the sister organ. We further notice that when the

hypertrophied sister organ is compared with that of the normal, the former shows a decrease of 6%. In short, the decrease of inorganic substance in the obstructed organ seems to be proportional to the degenerative process in the parenchym, namely the decrease of inorganic substance in the third stadium is greater by 15% than that in the first stadium, in which the degenerative process is not so advanced.

Total nitrogen content (Table VII and Fig. 5, A).

The total nitrogen content in fresh material of the obstructed kidney was 2.499%, that of the hypertrophied sister organ 2.666% and that of the normal 2.888%, on the total average of the experiment, so that in the obstructed organ it showed a reduction of 13.3% below the normal and 6.3% below the sister organ. If we compare the average value for each stadium, in the first stadium the total N content of the obstructed organ decreases 11.9% below the normal and 4.5% below the sister organ; in the second stadium it decreases 16.4% below the normal and 9.4% below the sister organ; in the third stadium it shows a decrease of 13.4% below the normal and 6.1% below the sister organ. The total N content of the hypertrophied sister shows also a decrease of 7.7% below the normal, on the average.

The content of the total N in the dry substance of the obstructed organ and hypertrophied sister organ varies nearly concordantly with that found in the fresh material. As the total average of the total N content in the dry substance amounts to 11.59% in the obstructed kidney, 11.94% in the hypertrophied sister kidney, and 12.88% in the normal organ, the total N in the obstructed organ shows a decrease of 10% below the normal and a decrease of 2.9% below the sister organ. The total N in the sister organ shows a decrease of 7.3% below the normal.

In the first stadium the total N of the obstructed kidney shows a decrease of 0.8% below the normal and an increase of 7.0% over the sister organ; in the second stadium it shows a decrease of 10.1% below the normal and also a decrease of 3.0% below the sister organ; and in the third stadium a decrease of 10.9% below the normal and a decrease of 3.9% below the sister organ. As previously mentioned, the decrease in the total N content of the fresh material of the obstructed kidney is 13.4% below the normal and 6.3% below the

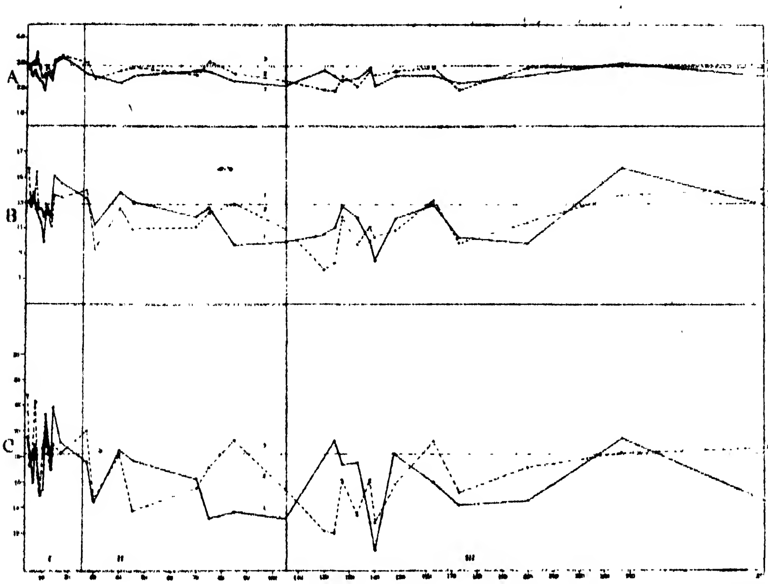

Fig. 5. Showing comparison of the total nitrogen in both kidneys after operation. (Constructed from Table VII)

Abscissa : days after operation.

Ordinate : Total nitrogen in each substance in per cent.

A. Total nitrogen content of fresh material.
1 : obstructed kidneys.
2 : sister kidneys.
3 : normal kidneys.

B. Total nitrogen content of dry material.
1 : obstructed kidneys.
2 : sister kidneys.
3 : normal kidneys.

C. Total nitrogen content of dry material free from fatty substances.
1 : obstructed kidneys.
2 : sister kidneys.
3 : normal kidneys.

hypertrophied sister organ, while the water content in the obstructed organ shows an increase of 1.7%, but in the sister organ it shows an increase of only 0.1% over the normal on the total average, though it shows an excess of 0.8% over the normal in the first stadium.

When the total N content of fresh and dry substance in the hypertrophied organ are compared with those of the normal, they show closer agreement with each other, for the change in water content

is almost negligible and the total N of fresh material shows a decrease of 7.7% below the normal and that of dry substance shows also a decrease of 7.3% below the normal as already described.

Furthermore, if the total N contents in fresh material and also in the dry substance of the obstructed organ is compared with those in the normal organ, the former shows a decrease of 13.4% and the latter of 10.0% below the normal. The latter decrease in nitrogen, means that in the various constituents of the dry substance nitrogen was relatively more decreased than the others in the diminution of the dry substance as in the obstructed kidney.

Total N in the dry substance excluding fatty substances.
(Table VII and Fig. 5 (B)).

If the total N content of the parenchym, excluding both water and fatty substances, is known, then the changes shown by the nitrogen will be perceived better. The nitrogen contents in fresh and dry substance fluctuate almost parallel to each other as is seen from Fig. 5.

The total N content of the obstructed organ free from water and fatty substances shows a decrease of 8.5% and that of the hypertrophied sister organ a decrease of 6.9% below the normal. Therefore, we can perceive some difference biochemically in the content of the total N between the obstructed and hypertrophied sister kidneys.

Fatty substances in the obstructed kidney.
(Table VII and Fig. 6, A.)

The content of the fatty substances or ether-alcohol soluble substances of fresh material from both obstructed and sister kidneys decreases in general from that of the normal, and this decrease in the obstructed organ is more striking than in the hypertrophied sister organ. In the obstructed organ it loses 20.0% against the normal, but in the sister organ it loses only 3.5% against the normal, that is, in the hypertrophied organ it loses only about 1/5 compared with that of the obstructed organ. Speaking more in detail, in the first stadium the content of fatty substances of the obstructed kidney shows a decrease of 16.5% below the normal and 13.5% below the sister organ; in the second stadium it reduces 27.6% below the normal and 25% below the sister organ; and in the third stadium it reduces

20% below the normal and 14.8% below the sister kidney. Fatty substances seem to be much reduced, probably due to the sudden disturbance in the blood supply or nutrition of the obstructed organ. For instance, on the 27th day it shows a decrease of 29.9%, on the 75th day 62.2%, on the 105th day 25%. And it seems likely that the more the degenerative process in the parenchym advances, the more striking is the reduction in the content of fatty substances.

Indeed, we find on the 237th day it reduces by 48.8% and on the 375th day it reduces by 76.2%. In the sister organ it shows a considerably smaller fluctuation compared with that of the obstructed organ.

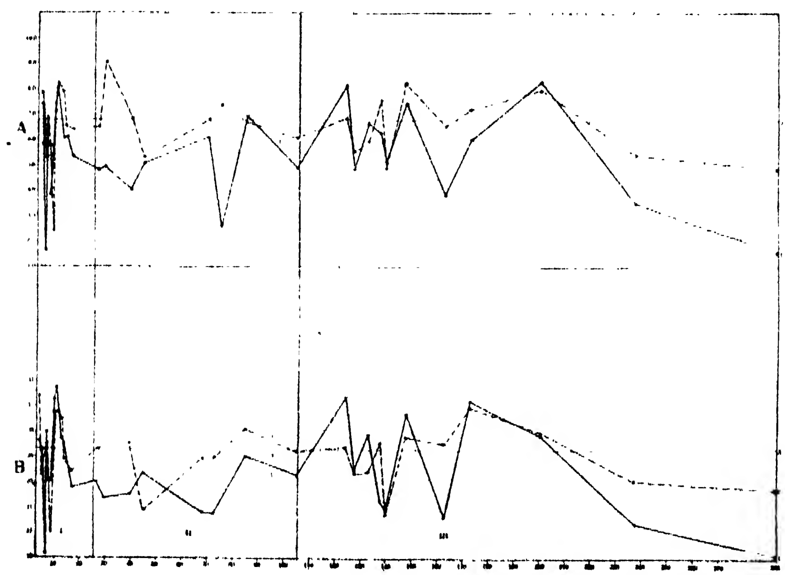

Fig. 6. Showing the content of fatty substances in both kidneys after operation. (Constructed from Table VII)

Abscissa : days after operation.

Ordinate : substance in per cent.

A. Content of fatty substances of fresh material.

1 : obstructed kidneys.

2 : sister kidneys.

3 : normal kidneys.

B. Content of fatty substances of dry material.

1 : obstructed kidneys.

2 : sister kidneys.

3 : normal kidneys.

The percentage content of the fatty substances in dry substance is 30.04% in the normal, 26.39% in the obstructed and 29.04% in the sister organ, on the total average. In the obstructed organ, therefore, it shows a reduction of 9.1% below the sister organ and 12.2% below the normal. In the sister organ it shows a decrease of 3.3% below the normal, therefore, it decreases only about one fourth of that in the obstructed kidney.

In the preceding chapter, we compared the losses of the fatty substances as expressed in percentage of the fresh weight, and we found that the loss in the sister organ is only one fifth of that in the obstructed organ.

From the decrease in dry substance and that in fatty substances, we may conclude that in the obstructed kidney, which is undergoing the striking degenerative changes in its parenchym, the content of dry substance is much decreased, and, moreover, among its constituents fatty substances are decreased much more remarkably than others. A similar tendency is also observed in the sister organ, but to a much smaller extent.

Pryin ('10) examined histo-chemically the distribution of fat in the uriniferous tubular system and observed that there was fat in the uriniferous tubular system, especially in the epithelium of the distal convoluted portion and the ascending limb of Henle's loop in the normal kidney, while in the epithelium which fell into atrophy due to various diseases there was scarcely any fat. In my experiment, in which provoked marked atrophy and replacement of the glandular parenchym by connective tissue was advanced, there appeared a remarkable reduction in the content of fatty substances, affirming biochemically Pryin's observation.

The content of chlorine in fresh material.
(Table VII and Fig. 7, A.)

The average content of chlorine such as NaCl found in 16 normal rabbits was taken as the normal control, as is in the other cases. The content of NaCl in both obstructed and normal organs was 0.27% on the average for the whole course of experiment, and that of the sister organ was 0.24%, showing a reduction of 11.0% below the normal or obstructed kidney in this instance.

If the whole course of experiment be divided into three stadiums as has already been done, we find in general that the NaCl content of the obstructed organ decreases by 7.4% in the first stadium and decreases also by 3.7% in the second stadium, while in the third stadium it increases by 14.8% over the normal. The NaCl content of the hypertrophied sister kidney was always smaller than that of

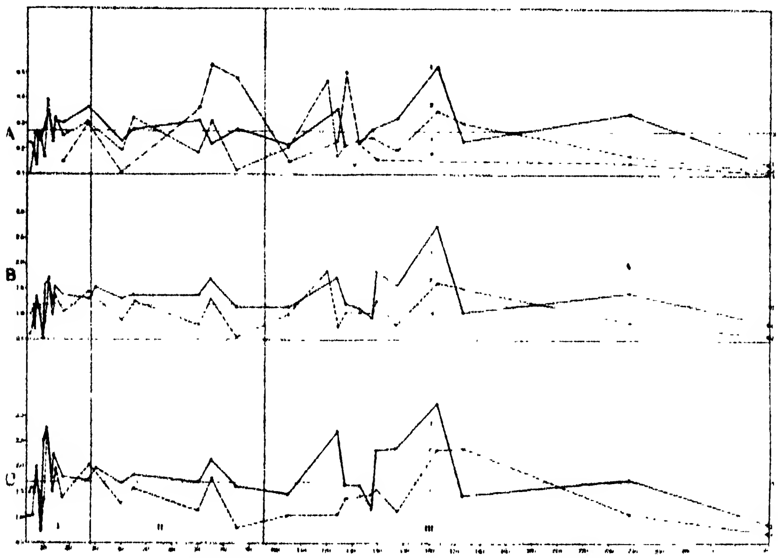

Fig. 7. Showing comparision of the content of chlorine (as NaCl) in both kidneys after operation.

Abscissa : days after operation.

Ordinate : substance in per cent.

A. Content of NaCl of fresh material and pelvic fluid.
1 : obstructed kidneys.
2 . sister kidneys.
3 : normal kidneys.
4 : pelvic fluid.

B. Content of NaCl of dry material.
1 : obstructed kidneys.
2 : sister kidneys.
3 : normal kidneys.

C. Content of NaCl of dry material excluding fatty substances.
1 : obstructed kidneys.
2 : sister kidneys.
3 : normal kidneys.

the normal, that is, it showed a decrease of 11.1% in the first stadium, 18.5% in the second stadium and only 3.7% in the third stadium. The NaCl content of the obstructed kidney was always greater than that of the sister organ, and the more advanced the stadium, the greater was the difference between them. Namely the NaCl content of the obstructed organ shows an excess of 4.1% in the first stadium, 8.3% in the second stadium and 29.1% in the third stadium over the hypertrophied sister kidney.

It is notable thereby that until the third stadium, when alteration in parenchym was not yet much advanced, the NaCl content of the obstructed and hypertrophied sister organ was always smaller than that of the normal, while in the third stadium, in which the obstructed organ was disintegrated strongly, the obstructed and hypertrophied organ showed an inverse tendency in the NaCl content.

The chlorine content of dry substance.
(Table VII and Fig. 7, B).

In the dry material the NaCl content of the obstructed organ increased by 9% over the normal, but in the sister organ it reduced by 15% below the normal. The NaCl content of dry substance excluding fatty substances in the obstructed organ showed an increase of 12%, while it showed, in the sister organ, a decrease of 17% below the normal.

4. Changes in the Stagnant Pelvic Fluid.

After the unilateral ureteral ligature, the total weight of the obstructed kidney increased markedly and relatively rapidly in the early stage of the experiment, especially in the first stadium, that is, for instance, on the 5th day it showed three times the normal weight, and 3.5 times on the 14th day, as is obvious from Table VII and Fig. 3. Thus it required only 27 days after the operation to reach its maximum (about 5 times), while as to the amount of the stagnant pelvic fluid it required considerably longer period before it reached the maximum, namely on the 5th day the pelvic fluid measured only 0.8 cc. on the 8th day 3.5 cc., on the 14th day 4.5 cc., on the 27th day 12 cc., and on the 70th day 30 cc. which was the maximum.

Afterwards it decreased gradually, for instance, being 13 cc. on

TABLE VIII. (1)

Biochemical findings on the pelvic fluid.

Stadium	Serial No. of rabbit	Days after operation	Weight of kidney (g.) Right	Weight of kidney (g.) Left	Weight of l. obstr. kidney excluding pelv. fluid (g.)	Pelvic fluid in the obstructed kidney: Amount (cc.)	pH	Specific gravity	Depress of freez. point	Total N (mg. in 100 cc.)	Nonprotein N (mg. in 100 cc.)
I	44	4	7.7	8.5	8.0	..	..	..	..	1780	..
	32	5	6.8	12.0	11.0	0.8	..	..	..	1522	..
	31	6	6.8	9.4	9.0		..	..	..	..	..
	7	7	6.1	11.3	9.0	2.0	5.81	1.032	..	1575	1500
	25	8	5.9	15.0	10.6	3.5	6.25	1.024	0.52	1450	1322
	51	9	7.8	10.5	9.7	0.5	..	..	..	1025	1000
	47	10	9.0	14.0	12.5	1.2	..	..	..	..	..
	5	11	9.4	15.0	11.0	3.6	5.71	1.033	0.88	2052	1940
	50	13	7.0	10.5	7.5	2.5	..	..	..	980	796
	10	14	6.5	19.0	13.5	4.5	..	..	..	..	..
	19	17	6.0	11.7	6.8	4.0	5.58	1.029	0.75	882	..
	33	27	10.0	35.0	14.0	12.0	6.72	1.016	0.65	518	198
Average			7.4	14.2	12.1	3.5	6.01	1.027	0.62	1309	1126
II	46	30	8.2	8.5	7.7	0.5	..	..	..	780	..
	43	40	6.5	9.2	4.5	4.0	7.12	1.015	..	504	344
	4	45	7.5	11.4	6.6	5.5	7.78	1.020	0.65	630	..
	28	70	8.5	36.0	6.0	30.0	6.21	1.019	0.65	455	199
	23	75	8.2	23.0	9.5	13.0	7.87	1.013	0.60	560	400
	27	85	14.5	19.0	4.5	14.0	7.45	1.023	1.25	833	465
	40	105	12.0	21.1	8.4	11.0	8.04	1.011	0.73	770	670
Average			9.3	17.3	6.7	11.2	7.41	1.017	0.78	646	416
III	39	120	7.0	5.1	2.0	3.0	5.19	1.023	0.70	602	410
	24	124	11.0	10.0	3.0	6.0	5.80	1.043	0.90	1344	224
	30	127	8.8	9.6	6.4	2.5	6.54	1.028	..	1078	118
	36	133	9.0	8.0	4.3	3.6	5.24	1.025	0.62	904	538
	37	138	7.0	5.5	5.0	..		..		..	.
	35	140	9.0	7.5	2.7	4.5	4.88	1.037	0.60	700	540
	34	148	6.9	13.1	8.7	4.5	6.63	1.012	0.55	476	402
	3	163	10.4	15.0	5.0	10.0	7.74	1.023	0.82	756	308
	29	173	10.4	3.7	3.7	..	..	..	..	1227	.
	20	200	8.5	10.7	3.0	7.3	6.88	1.024	0.60	546	338
	6	237	7.9	4.1	1.4	2.7	6.72	1.028	1.40	889	249
	2	375	9.7	10.0	2.3	7.0	7.26	1.035	1.00	1316	516
Average			8.8	8.5	3.9	5.1	6.29	1.026	0.79	894	364
Average of averages			8.4	12.7	7.0	6.1	6.54	1.024	0.76	968	594

Table VIII. (2)

Biochemical findings on the pelvic fluid.

Stadium	Serial No. of rabbit	Pelvic fluid in the obstructed kidney									
		Protein N	Ammonia N	Urea N	Creatinine	NaCl	Protein	Water content	Dry subst.	Organic subst.	Inorg. subst.
		mg. in 100 cc.						g. in 100 cc.			
I	44	..	..	..	..		..	..	..	..	..
	32	..	.	..	..	..	..	..	..	..	..
	31	..	..	..	..	..	..	..	..	..	..
	7	32	..	..	..	.	200	..	..	..	..
	25	128	..	..	..	.	800	..	..	..	..
	51	..	..	.	..	..	..	..	..	..	..
	47	.	..		..	..	..	..	..	..	..
	5	112	..	343	22		700	73.09	26.91	26.16	0.75
	50	184	.	118	26		1150	..	..	..	..
	10	..		.	..	.	..	..	..	..	..
	19	..	52	..		146	..	..	..	..	..
	33	320	154	..	26	301	2000	96.57	3.43	2.71	0.72
Average		115	103	231	25	223	969	84.83	15.17	14.45	0.74
II	46	..		.	..	..	..	..	..	..	..
	43	160	70	56	..	102	1000	96.11	3.89	3.13	0.76
	4	..	91	290	24		..	..	..	..	..
	28	256	45	..	17	409	1600	95.98	4.03	3.26	0.76
	23	160	54	141		532	1000	97.77	2.23	1.68	0.55
	27	368	70	362	15	468	2300	..	..	..	..
	40	100	28	578		146	625	98.73	1.27	0.87	0.40
Average		209	60	285	19	331	1306	97.16	2.85	2.24	0.62
III	39	192	50	..	..		1200	..	..	..	..
	24	1120	210			228	7000	87.85	12.15	11.77	0.38
	30	960	80	.	..	503	6000	..	..	..	..
	36	368	76	..	..	223	2300	93.57	6.43	5.26	1.17
	37		..	..	..		..	..	..	..	..
	35	160	..	.	..	152	1000	..	..	..	..
	34	74	35	..	..	..	462	..	..	..	..
	3	448	98	13	..	..	2800	94.48	5.52	4.55	0.97
	29	..	..	.		..	..	..	..	..	..
	20	208	..	..	..	..	1300	95.71	4.29	3.32	0.97
	6	640	54	60	..	143	4000	..	..	..	..
	2	800	50	60	.	110	5000	92.35	7.65	6.34	1.31
Average		497	81	44	..	227	3106	92.79	7.21	6.33	0.96
Average of averages		339	76		22	266	2118	92.93	7.09	6.31	0.79

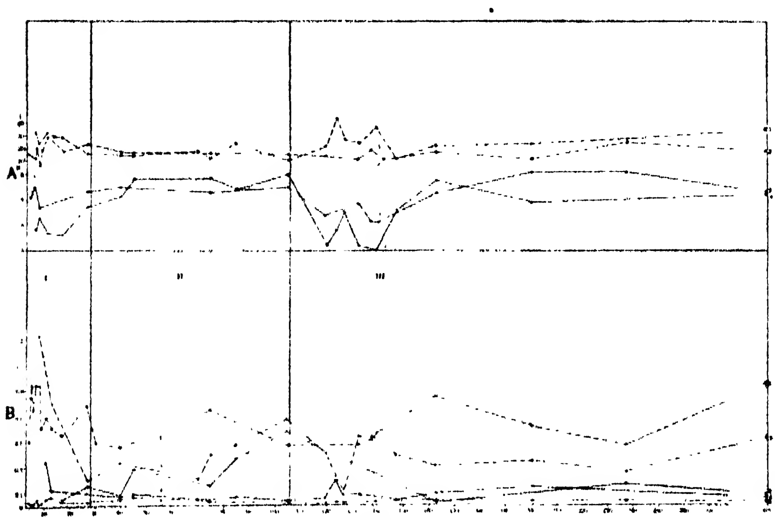

Fig. 8. A. Showing relation between the specific gravity and pH of the pelvic fluid and urine at the end of experiment. (Constructed from Table VIII)
Ordinate: I. sp. gravity, II. pH.
Abscissa: Days after operation.
1 : Sp. gravity of the pelvic fluid.
2 : Sp. gravity of the urine.
3 : pH of the urine.
4 : pH of the pelvic fluid.
B. Showing relation among nonprotein N., urea N., ammonia N. of the pelvic fluid and urine at the end of expriment.
Ordinate: Substance in per cent.
Abscissa: Days after operation.
1 : Urea N. in the urine.
2 : Urea N. in the pelvic fluid.
3 : Nonprotein N. in the pelvic fluid.
4 : Ammonia N. in the pelvic fluid.
5 : Ammonia N. in the urine.

the 75th day, 11 cc. on the 105th day, 7.3 cc. on the 200th day, and 7 cc. on the 375th day.

Moreover, it may be added that before and after the amount of the fluid reached the maximum, viz., from the 30th day to the 45th day and from the 120th day to the 145th day, it showed considerably small values, when the blood vessels in the capsula adiposa and on the surface of the ureter dilated remarkably. The relation just stated seems to indicate that the fluid was partly absorbed from the renal

pelvis probably by these vessels.

H-ion concentration of the pelvic fluid.

The pH of the stagnant pelvic fluid is remarkably low (pH=5.58) till the middle of the first stadium, indicating strong acid reaction, but it increases its value gradually, showing decrease in acidity in accord with the increase of the amount of the pelvic fluid. At the beginnig of the second stadium it passes the neutral point (pH=7.12) and becomes alkaline with the increase of the pelvic fluid. At the beginning of the third stadium, in which the amount of the pelvic fluid and the weight of the renal parenchym begin to decrease, the fluid shows again strong acidity, showing the minimum pH to be 4.88, followed by recovery to approximate neutrality, which continues until the end of the experiment. That is, on the 140th day after operation, the pH reaches the minimum (pH=4.88), then increases and on the 148th day shows pH=6.54, and still continues to increase and exceeds the neutral point (7.74 on the 163th day). In the later periods until the end of the experiment, the pH value fluctuates quite near neutrality.

The pH value of the urine, which was collected just before the animal was killed, changed in parallel with that of the pelvic fluid, but the changes of the former were always smaller than those of the latter, thus keeping the pH of the urine nearer to neutrality than that of the pelvic fluid.

This may easily be understood by supposing that part of the disintegration product in the obstructed kidney is accumulated and concentrated in the pelvic fluid to cause a remarkable change in pH, while on the other hand it is partly carried away by the blood stream and excreated by the sister kidney in a more diluted concentration.

It is conspicuous and interesting to note that the pH changed exactly in the reverse to the change of the specific gravity. That is, the greater the specific gravity, the smaller was the value of the pH. This condition was striking especially in the first stadium and in the period extending from the 120th to the 140th day, when the protein content also reached the maximum.

The depression of the freezing point of the pelvic fluid.

There was a parallelism between the changes in the depression

of the freezing point and that of the specific gravity. The depression of the freezing point of the fluid (0.76°) was lower by 30% than that of the urine (1.07°). While the specific gravity of the pelvic fluid is greater than that of the urine, the depression of the freezing point of the former is lower than that of the latter.

This is probably due to the fact that the pelvic fluid contains much less salts which are osmotically more active and more responsible for causing depression of the freezing point, although it contains proteins which are by far less active osmotically and thus produce much depression.

According to REUSS, the depression of the freezing point of transudate and exsudate in man lies between 0.51 and 0.80. From this fact and from the value obtained in the present study together with histological observation, therefore, the stagnant pelvic fluid may be regarded rather as a transudate.

The specific gravity of the pelvic fluid.

The specific gravity of the pelvic fluid showed fluctuation as did that of the urine, but the average value for the pelvic fluid (1.024) was greater by 0.009% than that of the urine (1.015) collected immediately before the death of the rabbit. As already described, it is remarkable that the specific gravity of both the pelvic fluid and urine showed changes reverse to that of pH of both the fluid and urine.

According to the observation of V. REUSS, the specific gravity of the serous exsudate is 1.018, but that of the transudate lies below it.

The considerably higher value of the specific gravity of the pelvic fluid of the rabbit suggests that its formation may be different from the transudative and exsudative processes in the other parts of the body.

Total-nitrogen content of the pelvic fluid.

Until about the 17th day after operation the content of the total N. of the fluid fluctuated considerably and was greater than in subsequent stages, showing 1–2 g. per 100 cc. Afterwards it tended to decrease gradually, until about the middle of the second stadium, showing 450 mg. per 100 cc. on the 70th day, then increased gradually until the earlier period of the third stadium, showing 1.3 g. per 100 cc.

on the 124th day. After this the content again decreased to the minimum of 476 mg. per 100 cc. on the 148th day, and the later course showed a general tendency of increase in nitrogen until the end of the experiment. The average value for the entire course showed 968 mg. per 100 cc.

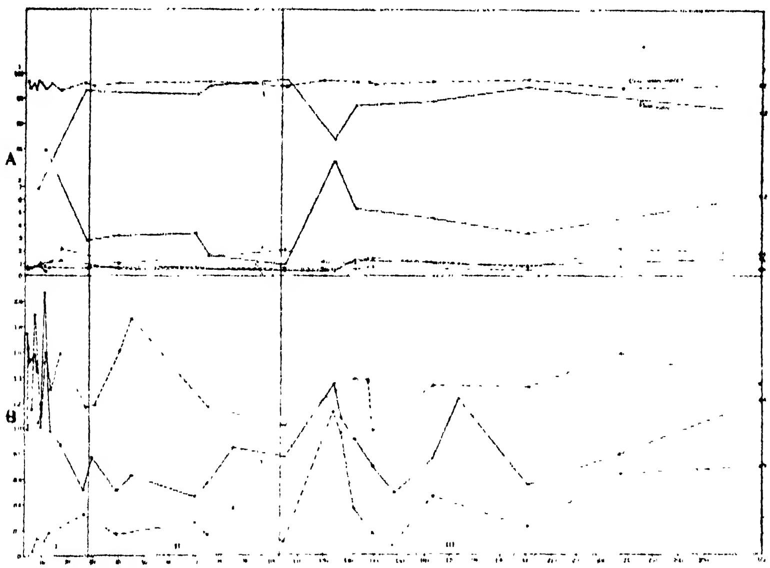

Fig. 9. A. Showing relation of the contents of water, organic and inorganic substances and total N. of the pelvic fluid and urine at the end of experiment. (Constructed from Table VIII)

Orninate : I. and II. Substance in per cent.

Abscissa : Days after operation.

1 : Water content of the urine.

2 : Water content of the pelvic fluid.

3 : Organic subst. of the pelvic fluid.

4 : Organic subst. of the urine.

5 : Inorg. subst. of the urine.

6 : Inorg. subst. of the pelvic fluid.

B. Showing relation between the contents of protein N. and total N. of the pelvic fluid and urine at the end of experiment.

7 : Total N. of the urine.

8 : Total N. of the pelvic fluid.

9 : Protein N. of the pelvic fluid.

Protein content of the pelvic fluid.

After operation the protein content in the fluid gradually increased until the end of the first stadium. In the second stadium it fluctuated to some extent, but did not show a considerable increase, while it fluctuated remarkably and showed a great increase on the whole.

Except in the first stadium, the changes in protein content proceeded parallel to that of the total nitrogen. It was stated already that the content of the total nitrogen in the pelvic fluid at the earlier stage of the experiment was greater, and thus one rather might correspondingly anticipate greater protein content in this same stage. In fact, however, we found a relatively small amount of protein at the earlier stage, which gradually increased as the days advaced.

This apparent disagreement in the results given by the total nitrogen and total protein may be explained from the fact that in the very early stage the pelvic fluid is still urinous in nature, and consequently a relatively large quantity of urea nitrogen would be contained in it. After the beginning of the third stadium (about the 105th day) the protein content increased parallel to the degenerative alteration in the renal parenchym, and it reached the maximum when the parenchymatous degeneration was markedly advance. Following this maximum the protein content again showed a decrease for the next three weeks, due probably to the absorption through the vascular system. The average value of protein nitrogen in the pelvic fluid was 339 mg. per 100 cc., which corresponds to 2.124 g. of protein per 100 cc.

According to LASSER, the protein content in the transudate was 3–4%, while in the exsudate it was 6.5–8.0%.

RUNEBERG proposed the following fomulae for calculating the protein content of the transudate and exsudate from the value of the specific gravity of the fluids under consideration.

a) P (%) = 3/8 (s–1000) - 2.73 (for transudate)

b) P (%) = 3/8 (s–1000) - 2.88 (for exsudate)

(s is specific gravity and P the protein content)

If the value of the specific gravity obtained from the pelvic fluid of the rabbit is now inserted into each of the fomulae given above, we obtained the values of 6.26% and 6.12% respectively. However, the actual amount of protein found in the pelvic fluid was only 2.124 g.

per 100 cc. and accords with neither of these two values. This discrepancy indicates the invalidity of the formula for the case of the pelvic fluid in experimental hydronephrosis and suggests that the properties of the pelvic fluid may be far different from those of both simple transudate and exsudate, and the extraordinarily high value of the specific gravity, which cannot be attributed to the amount of proteins alone, may be due to the presence of a large amount of substances other than proteins.

Urea content of the pelvic fluid.
(Table VIII and Fig. 8 B. 1 and 2.)

Looking over the result of my experiments, changes in the content of urea in the fluid showed a parallelism to that of the non-protein N., the main part of which is represented by the urea nitrogen. The urea content gradually decreased at first, then increased until the end of the second stadium, and again decreased gradually in the third stadium, as was already observed by HERMANN ('59).

This change in urea content, as a whole, is the reverse of that in protein content. The average of urea nitrogen for the whole experimental period was 202 mg., which corresponds to 424 mg. of urea per 100 cc.

Ammonia content of the pelvic fluid.
(Table VIII and Fig. 8. B. 4 and 5.)

The content of ammonia nitrogen in the pelvic fluid, on the average for the entire course of the experiment, was remarkably greater than that in the urine. The former was 76 mg. contrasted with 32 mg. per 100 cc. in the latter.

Creatinine.

With regard to creatinine N content in the pelvic fluid, it showed so much inconstancy, that we refrained from a discussion of its general significance, but on the average for the whole course of the experiment its content was about 22 mg. in 100 cc. contrary to the observation of HERMANN, who found a much greater amount, which is close to the urine, in the pelvic fluid of hydronephrosis. The amount found

in the urine of rabbits was about 30 mg. N per 100 cc and it was usually stated to be 37 mg. N in 100 cc. human urine (LANDOIS).

The content of sodium chloride in the pelvic fluid and parenchym of the obstructed kidney.

On the 27th day after operation, when the weight of the obstructed kidney reached the maximum, showing 6 times the weight of the normal, the NaCl content of the remaining parenchym was also the maximum, showing an increase of 33.3% over the normal. On the 70th day or at the middle of the second stadium, when the amount of the pelvic fluid reached the maximum and the weight of the remaining parenchym alone reduced to below the normal, the NaCl content of the pelvic fluid was still further increased, showing an increase of 50% over the normal. In the third stadium, in which the degenerative process in the parenchym was remarkably advanced and the weight of the remaining parenchym was also decreased, the NaCl content in the parenchym did not show a correspondingly greater reduction, while the NaCl content of the pelvic fluid in the stadium showed a gradual reduction. For instance, on the 140th day it showed a reduction of 42%, on the 237th day 45%, and on the 375th day or at the end of the experiment it showed a reduction of 58% below the normal.

The average value of the NaCl content in the parenchym was almost equal to that in the pelvic fluid, these values respectively being 0.27% and 0.26%.

The NaCl content of the urine, however, was very small or negligible, if any, in all cases examined, as is usually observed in herbivorous animals.

The contents of water, dry substance, organic and inorganic substances. (Table VIII and Fig. 9. A. 1–6.)

The content of the substances enumerated here showed remarkable fluctuation, according to the number of days elapsed after operation and to the individuals tested. Their average values show 92.93% in water content, 7.09% in dry substance, 6.31% in organic substance, and 0.79% in inorganic.

Some characteristic points of the stagnant pelvic fluid compared

with the urine are shown briefly in the following:

1. The pH of the pelvic fluid is much lower than that of the urine in the early period, showing strong acidity, and tends to be more acid in reaction even at the end of the experiment.

2. The specific gravity of the pelvic fluid is considerably greater than that of the urine and also shows a somewhat greater consistency.

3. Depression of the freezing point of the pelvic fluid is less than that of the urine.

4. The pelvic fluid contains protein and chlorine in considerably large amount, which cannot be proved in the urine. Furthermore, their contents increase in accordance with the degree of atrophic process in the parenchym.

5. The urea content of the pelvic fluid is considerably large in the early period, showing a tendency of a gradual decrease in accord with the atrophy of the organ which encloses the fluid.

6. The ammonia content of the pelvic fluid is also larger remarkably than that of the urine.

7. The total N. content of the pelvic fluid is almost equal to that of the urine in the early period, but afterwards it decreases considerably.

8. The creatinine content of the pelvic fluid is smaller than that of the urine, showing strong fluctuations.

9. The accumulated pelvic fluid in the later stadium often contains some crystals which are found in the normal urine.

IV. GENERAL CONSIDERATION.

1. Classification of Stages in Hydronephrosis based upon its Histo-Anatomical and Biochemical Changes.

In the previous chapter, we classified the entire course of the experiment extending over a year into three stadiums according to changes in the weight of the parenchym of the obstructed kidney as well as the characteristic histological changes. Furthermore the chemical changes in the pelvic fluid and parenchym were treated also in each stadium respectively.

Now we briefly enumerate here some characteristic points in each stadium.

TABLE IX.

Summary of biochemical findings on the kidneys.
(average values)

	Increase in weight					Water content			Dry substance		
	Right	Left (obstructed)									
		Total	Parenchym		Pel. fl.	(%)			(%)		
	(%)	(%)	(g.)	(%)	(cc.)	Right	Left	Ave.	Right	Left	Ave.
Normal						77.49	77.37	77.43	22.49	22.61	22.55
I stadium (1–27th day)	55.6	200.5	5.4	114.7	3.5	78.04	79.99		21.95	20.00	
II stadium (28–105th day)	39.3	157.0	0.1	2.5	11.2	76.77	78.71		23.23	21.29	
III stadium (106–375th day)	31.6	25.5	-3.3	-48.3	5.1	77.32	77.91		22.68	22.09	
Total average (1–375th day)	42.6	128.0	0.8	26.3	6.1	77.48	78.74	78.11	22.52	21.26	21.89

	Organic subst. (%)			Inorg. subst. (%)			Total nitrogen								
							fresh weight (%)			dry subst. (%)			dry subst. excl. fatty subst. (%)		
	R.	L.	Ave.	R.	L.	Ave.	R.	L.	Ave.	R.	L.	Ave.	R.	L.	Ave.
Normal	20.82	21.25	21.07	1.52	1.50	1.51	2.87	2.91	2.89	12.84	12.91	12.88	18.43	17.95	18.19
I stad.	20.35	18.58		1.49	1.45		2.88	2.55		13.23	12.78		18.74	18.19	
II stad.	21.71	19.87		1.41	1.41		2.63	2.42		11.39	11.58		16.26	15.23	
III stad.	21.25	20.95		1.36	1.25		2.47	2.50		10.97	11.47		15.53	16.02	
Average	21.02	19.83	20.42	1.42	1.35	1.39	2.67	2.50	2.58	11.94	11.59	11.77	16.94	16.65	16.79

	Sodium chloride									Fatty substance					
	fresh weight (%)			dry subst. (%)			dry subst. excl. fatty subst. (%)			fresh weight (%)			dry subst. (%)		
	R.	L.	Ave.	R.	L.	Ave.	R.	L.	Ave.	R.	L.	Ave.	R.	L.	Ave.
Normal	0.25	0.29	0.27	1.19	1.25	1.22	1.61	1.79	1.70	6.93	6.81	6.87	30.49	29.58	30.04
I stad.	0.24	0.25		1.06	1.21		1.52	1.84		6.53	5.73		29.61	29.60	
II stad.	0.22	0.26		0.95	1.35		1.26	1.77		6.88	4.97		28.67	23.69	
III stad.	0.26	0.31		1.11	1.48		1.46	1.93		6.69	5.65		28.85	25.88	
Average	0.24	0.27	0.26	1.04	1.33	1.23	1.41	1.86	1.65	6.63	5.49	6.06	29.04	26.39	27.72

I. Stadium: This stadium covers the period extending from the 1st to the 27th day after obstruction of the left ureter.

A. Changes in the weight of the kidney.

In this period the weight of the obstructed kidney is somewhat heavier than those of the normal and hypertrophied sister kidneys and the pelvic fluid, that is, the obstructed kidney enclosing the pelvic fluid shows an increase of 200.5% while that of the remaining parenchym without the fluid shows 114.7% compared with the weight of the normal kidney. While the hypertrophied sister kidney shows an increase of only 55.6% on the average, as is obvious from Table IX.

B. Changes in the histological structures.

These consisted of gradual dilatation of the lumen of all the uriniferous tubules and BOWMAN's capsule.

C. Chemical changes in the pelvic fluid in comparison with those in the parenchym.

The values of the specific gravity, the contents of the total N., non-protein N, NH_3, creatinine, dry substance and organic substance of the pelvic fluid in this stadium are the greatest of all three stadium, while that of the contents of urea and inorganic substance is intermediate. The values of the pH, the depression of the freezing point, and the contents of protein, NaCl and water in this I. stadium are the smallest of all the stadiums.

The contents of water, inorganic substance, total N., and fatty substance of the obstructed renal parenchym in this stadium are the greatest of all three stadiums, but the contents of dry substance, organic and NaCl are smallest.

II. Stadium: This covers the period extending from the 28th to the 105th day.

A. Change in the weight of the kidney.

In this period the weight of the remaining parenchym of the obstructed kidney is nearly equal to that of the normal, showing a slight increase of 2.5% on the average, while the total weight of the organ shows an increase of 157% over the normal, but it shows a decrease of 43.5% below that in the first stadium. The pelvic fluid amounts to 11.2 cc. on the average, 3 times more than in the first stadium, showing the greatest amount.

B. Changes in the histological structures.

These consisted of progressive atrophy or disintegration of the grandular elements and gradual increase of proliferation of the interstitial connective tissue. C. Chemical changes in the pelvic fluid in comparison with those in the parenchym.

In this stadium the value of the pH and the contents of urea, NaCl and water in the pelvic fluid are the greatest of all three stadiums, but the protein content, non-protein N, and the depression of the freezing point are intermediate. The specific gravity and the contents of the total N, NH_3, dry substance, organic, and inorganic substance in this stadium are the smallest of all three stadiums.

The contents of water, dry substance, organic, inorganic and NaCl of the obstructed renal parenchym in this stadium give intermediate values of all stadiums, while the contents of the total N. and fatty substances are the smallest.

III. Stadium. This covers the period extending from the 106th to the 375th day or the end of the experiment.

A. Changes in the weight of the kidney.

In this last period the conditions in the weight are just reversed to those of the first stadium, namely, the weight of the remaining parenchym excluding its pelvic fluid is far smaller than that of the normal, showing a decrease of 49.3% below the normal, 51.8% below that in the second stadium and 164% below that the first stadium.

While the total weight of the obstructed kidney still shows an increase of 25.5% over the normal on the average, it shows a decrease of 132% below that in the second stadium and 175% below that in the first stadium.

The amount of the pelvic fluid measures 5.1 cc. on the average, showing a considerable decrease when compared with the preceding stadiums.

B. Changes in the histological structures.

Replacement by proliferated connective tissue of glandular elements of the kidney was noted.

C. Chemical changes in the pelvic fluid in comparison with those in the parenchym.

In this stadium the contents of protein and inorganic substance of the pelvic fluid are the greatest of all three stadiums. The values of the pH, specific gravity and depression of freezing point and the

contents of NaCl, the total N, NH_3, water, dry substance and organic substance are intermediate of all three stadiums. The contents of urea and non-protein N are the smallest.

The contents of dry substance, organic and NaCl of the renal parenchym in this stadium are the greatest of all three stadiums, while those of the fatty substances and total N. are intermediate. The contents of water and inorganic substance are the smallest of the three stadiums.

2. Histo-anatomical Considerations.

Findings in the thirty-one cases show that the pathological changes do not always run parallel to the duration of experiment as already mentioned, but in the majority of the cases the degenerative process seems in general to advance gradually in accordance with the days elapsed. The classification of the degenerative changes in the affected kidney after the unilateral ligature of the ureters to periods has already been attempted by some investigators. For instance, STRAUSS and GÉRMONT ('82) divided the entire course of hydronephrosis into two periods based upon its histological observation, SUZUKI ('14) and KAWASOE ('12) to three periods, FABIAN ('04) to four periods, and HABUTO ('18) to five periods.

The present writer classified changes in hydronephrosis into three periods, as described above. In those periods, the following histological changes can be pointed out in summary.

Stadium 1. Gradual dilatation of the lumens of the uriniferous tubular system and enlargement of the BOWMAN's capsule.

Stadium 2. Progressive atrophy and disintegration of parenchymatous components and proliferation of the interstitial connective tissue.

Stadium 3. Replacement by proliferated connective tissue of glandular eléments of the kidney.

The results of my experiments show that in general the degenerative change in the parenchym after operation increases step by step, but that there are differences in the degree and progress of histological changes of the uriniferous tubular system according to the portions of the latter, and also that even in the same portion there is sometimes a noticeable difference due probably to the individual variation

of the animals. In the experiments, which extended over a year, the glomeruli in general were very resistant and did not suffer remarkable change until the general degenerative process was greatly advanced. These observations are in accord with the results of previous investigators.

The dilatation and connective tissue proliferation of BOWMAN's capsule and general parenchymatous atrophy occur always after a certain period, but we find no hyaline alteration especially in the glomeruli throughout our experiment, differing from some nephritic atrophy. However, the distribution and arrangement of the glomeruli are disturbed, and they are scattered and sometimes in groups, and their form and size are sometimes irregular, and varying, owing probably to the degree of the proliferation of connective tissue in the neighbouring parenchym, which will exert pressure upon the glomeruli. As soon as the disintegration of the glandular elements and the replacement of the latter by proliferating connective tissue have considerably advanced, the glomeruli also diminish in size strongly, change their form, and finally arrange themselves compactly side by side in the outer layer of narrow cortex.

According to HAGEMANN, in an advanced stage of hydronephrosis there is a strong cellular infiltration in the interstitial tissue, and the glomeruli all present an appearance of atrophy and degenerative shrinkage, and the wall of the blood vessel in the kidney thickenes, showing an anaemic appearance in the organ. SUTER and KAUFMANN found also such appearances.

ORTH ('10) pointed out that the glomeruli were maintained for a very long period and that they did not completely lose their original function — e. g. filtration — even at the most advanced period of hydronephrotic atrophy, and CONHEIM, HOLSTE, GUYON and ALBARRAN, GÜTERBOCK, MENDELSON, SANER, LINDEMANN, etc. also described such an observation.

ZERFELL ('12) with GRIFITH distinguished two kinds of atrophy of the glomeruli, namely (1) simple atrophy and (2) atrophy with hyaline degeneration, as in interstitial nephritis.

LINDEMANN ('98), as already stated, showed that glomeruli are very persistent in general, and that the reason why the glomeruli situated in the central portion become atrophied more easily than the

others was that the vascularisation of the parenchym was very different depending on the portion concerned, and that the medullar portion, which was almost wholly supplied by the arteria renalis, was also easily atrophied, for the arteria renalis rarely formed anastomosis with the blood vessels of the renal pelvis and ureters.

Many investigators show that the dilatation of the lumen in the uriniferous tubular system occurred first after ligation of the ureter, and in my experiment, I have found the same thing to be true. Of the uriniferous tubular system, the collecting tubules, the distal convoluted portions and HENLE's loops are most dilated at first respectively while the dilatation is partial and of slight degree in the proximal convoluted portion. SUZUKI ('14) considered the dilatation of the lumen of the uriniferous tubular system as a primary change in hydronephrosis, and in my cases the dilatation takes place somewhat later than SUZUKI's findings. In other points my observations almost accord with his. As to the cause of the dilatation of the uriniferous tubule, it seems to be ascribable mostly to the urinous fluid accumulated in the pelvis and the stagnant pelvic fluid seems to originate mostly from excrete of the glomerular unit system; for it is a well-known fact that when the function of the kidney is once disturbed, the kidney excretes thinner urine in a greater amount, instead of the thicker urine in a smaller amount of the normal condition, for adjustment of metabolism. But when the kidney loses the ability of adjustment, then it may excrete thinner urine in a small amount, leaving end-products in the body. Actually I find in my cases that the amount of the pelvic fluid is greater in the earlier period, when the degenerative process or functional disturbance of the kidney is not yet so advanced, owing probably to the same cause as above mentiond. Furthermore, PONFICK points out either transudate from the blood vessels of the dilated ureter or secrete from the mucous membrane of the dilated pelvis, as the factor of the increase of the pelvic fluid, but we cannot anticipate that they are an important part of the increase, as is obvious from their topographical and histological relation.

As to the changes in the proximal convoluted portion, most investigators hitherto have considered that it enlarged once at first, and then atrophied. Concerning the essential nature of the atrophy, they ascribed the cause sometimes to the disturbance of the blood circula-

tion, sometimes to depression and sometimes to inactivity.

HABUTO ('18) insisted that the atrophy or collapse of the proximal convoluted portion was an inactivity-atrophy caused by cessation of its function due chiefly to the pressure of the accumulated urinous fluid.

In my experiment, the portion which showed atrophy in the very early stadium was relatively small, and the other portions showed their original appearance with a slight dilatation of their lumens, therefore, it cannot be denied that there is a compression-atrophy.

In the uriniferous tubules, the internal pressure increases with the increase of the content in the dilated pelvis and their lumen dilates up to various degrees in accordance with their topographical orders; namely, the collecting tubules, which open in the dilated pelvis, dilate first, then the distal convoluted portions and HENLE's loops, and finally the proximal convoluted portions, as already mentioned. As to the degree of their dilatation, it is also greatest in the collecting tubules, next in the distal convoluted portions, and then in the ascending limb of HENLE's loops. Its chief cause, as previously showed, is probably the stagnant urinous fluid in the pelvis, and the fluid seems to act on the portion which lies nearest to the pelvis, and thus dilates gradually the whole uriniferous tubular system in ascending order.

The blood pressure in the afferent vessel seems to be remarkably higher than that of the efferent vessel, as is seen also from the topographical structure, and COHNHEIM actually found that urine excretion ceased when the pressure of the fluid reached 50–60 mm. Hg. in the renal pelvis in a sudden uretral blockade.

In the hydronephrotic atrophy, the glomeruli, as previously often stated, maintain their structure very long and well, containing some blood in their capillary loops. Therefore, they at least seem to continue the filtration until the pressure in the capsule of BOWMAN is equalized to the pressure in the afferent vessel. The urinous fluid thus produced raises the internal pressure of the pelvis and leads to further dilatation of the pelvis, to flattering of the epitherilia of the dilated uriniferous tubules, and finally to their atrophy.

With regard to the atrophy of the tubular system, all the uriniferous tubules do not fall simultaneously into atrophy, and even in the same portion of the tubules there is difference according to the

period passed or the degree of atrophy. For instance, of the proximal convoluted portions its distal part seems to fall into atrophy most easily and strongly.

In my cases, some of the collecting tubules maintained their normal form for considerably longer period, as SUZUKI also found in his study. The portions fall into atrophy in the following order: the proximal convoluted portion, the HENLE's loop, the distal convoluted portion, the collecting tubule. This above order seems to be wholly reversed in the case of the dilatation of the lumen of the tubules.

PONFICK and others described that they found noticeable differences in the degree of atrophy in the hydronephrotic process according to its portion, but they did not point out that there was a certain regularity in the order of atrophy among these portions. In my cases, I can not help recognizing such in consistancies in the degree and order of atrophy in observation of each case separately, but in generalising it is found that there is a certain regularity of them, that is, the atrophic process is most striking in the portion adjoining the renal hilum, but in the other portion it is relatively slight, as SUZUKI observed.

KITANI ('11) carried out experiments on hydronephrosis and concluded that histological change of the organ is not identical with that in the so-called nephrosclerosis but should be considered rather as mere atrophy.

ORTH ('10) studied also the change of hydronephrosis, and observed that desolation and shrinkage of the glomeruli were not the essential features of hydronephrotic atrophy, but rather accessory in character.

As to the mechanism of such destructive processes, there are many interpretations.

According to PONFICK the disturbance in the blood-circulation occurs not only owing to the mechanical cause but also to the reflex action of the vaso-motor nerve caused by increased urinary components which are arrested in the kidney. ORTH ('10) considered the nutritive disturbance caused by the decrease in blood supply as a chief cause of the atrophy, and observed a colloidal secretion on the epithelial cells in the inactivity-atrophy (Vascular nephrosclerosis), which, however, was not the case in the hydronephrotic atrophy.

The stasis or arrest of the venous blood of high degree causes a

disturbance in gas-exchange in tissue and in the supply of nutrition, and leads to necrosis. There is no question that strong mechanical or chemical action is fatal to the living tissue and even slight mechanical or weak chemical action deprives the vitality of the tissue, if it comes in contact for a long period. The epithelial cells of the uriniferous tubules die in two hours after the ligature of the renal artery, but the intertubular connective tissue still maintains its vitality, and when the binding of the artery is released two or three hours afterward, it shows a reactive regeneration.

GOLDMANN ('88) found that on microscopical examination of spleen autolyzed for eight days the pulp cells showed changes, while the nuclei in Malpighian bodies were well preserved. After fourteen days, they were still retained, but in the remainder of the tissue the nuclei disappeared almost completely. KLEBS ('90) described two forms of nuclear changes, karyolysis and karyorrhexis, in the mycotic destruction of nuclei. SCHMAUS and ALBRECHT ('95) observed that after ligation of the renal vessels the first change was pyknosis, followed by karyorrhexis. CORPER ('12) found, in his comparative study of the chemical and histological changes in autolysis after complete ligation of the splenic pedicle, that in dog's spleen autolyzed two days, *in vivo*, the trabeculae, from which all vestiges of nuclei had disappeared, could still be differentiated from the pulp, the former having lost affinity for hematoxylin; in the spleen after autolysis for ten days it showed a typical necrotic tissue with no nuclei and only the remnant of the trabeculae and splenic pulp. In the spleen 40 days after operation, the splenic remnant was found to be made up of typical scar tissue.

HEDIN and his co-worker ('03) observed two distinct proteolytic enzymes in the spleen. Therefore, it is reasonable to consider that the destruction of the affected tissue was induced partly by the autolytic activity of such enzymes.

The above descriptions are observations of some workers on the feature of the glomeruli as well as the uriniferous tubular system in hydronephrotic atrophy and allied changes, and they are mostly in accord with my own observations. As to the causes of the desctruction and shrinkage of the glomeruli, they seem, as in the uriniferous tubules, not to be ascribed to a single mechanism, and it can not be denied that the causes are at least related to the disturbance of

the nutrition, the increase of tho interstitial connective tissue, primary and secondary atrophy due to the pressure caused by the increase of the fluid accumulated in the renal pelvis, and inactivity.

The proliferation of the interstitial connective tissue. In the early stadium or up to the middle of the second stadium of the hydronephrotic alteration, the multiplication of the interstitial connective tissue cannot yet be perceived, but as soon as the epithelium of the proximal convoluted portion falls into atrophy or collapse, the cellular elements of the nature of connective tissue begin to proliferate in the neighbourhood. It is obvious that the more the atrophic process advances in the glandular parenchym, the more the proliferation of the connective tissue bocomes active.

From the observation of the above fact, the proliferation seems to have the significance of a supplement for the parenchymatous loss. Besides, it can not be denied that in atrophy of the epithelium of the uriniferous tubules the epithelium may produce some chemical substances, which together with urinous fluid accumulated in the renal pelvis, stimulate the connective tissue of its neighbourhood, leading to active proliferation. Furthermore, this urinous fluid just mentioned causes the mechanical depression which leads to the change of tension among the cells. The oedematous infiltration in the interstitial tissue also can be reckoned as a factor in the proliferation of the connective tissue.

The alteration of the blood-vascular system in the kidney. The wall of the blood vessels thickens in general, and the lumen narrows itself remarkably, but hyaline degeneration is rarely seen. KAUFMANN ('04) considered the cause of the thickening partly as in inflammatory, as in other interstitial inflamations, but mostly as reactive hypertrophy, due to the increase in blood-pressure resulted from stasis in the venous vessels and to the functional increase in the arterial vessels. As the hydronephrosis was produced as aseptically as possible in our experiments, participation of acute inflamation can not be taken into consideration and the thickening must have resulted mostly from reactive hypertrophy against the over-pressure in the vessels.

Distribution of the blood in the affected kidney. As to the distribution of the blood in the affected organ after aperation, the opinions of the investigaters do not always agree, for instance. ALBARRAN,

AUFRECHT, ENDERLEN, KUSTER, ORTH, POSNER, ROSA, SUZUKI and others found stasis, while LINDEMANN observed that there was a difference according to the animals examined, e. g. in the dog stasis was remarkable, but in the rabbit it was very slight and temporary, and passed immediately into anaemia. OSHIMA and HOZUMI described that in the early period stasis increased with the acute obstruction of the ureter, but twenty-four hours after operation it was followed by anaemia. In my own cases stasis was generally seen in the early stadium, while anaemic conditions of parenchym increased later gradually with the days elapsed.

Hemorrhage and pigment in the disintegrated parenchym. With regard to hemorrhage in the parenchym of hydronephrotic atrophy, there are also different opinions, namely, some insist that they saw hemorrhage in the disintegrated parenchym, but others claim, on the contrary, that they never found it. Concerning to pigment in the parenchym, some consider that it originates from the blood, but others maintain that it is derived from urine. ENDERLEN often found such pigment in the parenchym of the kidney and renal pelvis, and considered that it originated probably from the blood; SUZUKI stated, after examination of ENDERLEN's microscopical preparations, that the characteristic pigment found therein had probably no relation with the blood or hemorrhage, but it probably originated from the urinary pigment. PONFICK ascribed the hemorrhage in the uriniferous tubules, in the later period of hydronephrosis, to the increase of the disturbance in the blood circulation. KITANI observed hemorrhage in the interstitial tissue, and as to the pigment in the epithelium of the proximal and distal convoluted portions, he doubts that it originated from the blood, though he was not able to determine whether it originated from the urinary pigment or not.

In my cases, hemorrhage and pigment were also observed, but their locality, is not definite. Therefore, it seems to me that the origin of the pigment may sometimes be traced in the blood, as mention by ENDERLEN; and sometimes in the urinary pigment, as was already observed by some authors like SUZUKI, PONFICK and others.

Regeneration. It is generally recognized that the kidney is an organ which has a great ability for hypertrophy, as does the heart, but its ability for regeneration is not so remarkable. However, when

the interstitial connective tissue is not much affected, the epithelial cells of the tubules can regenerate completely.

ASCHOFF observed that when the membrane propria, the network of the connective tissue, the capsule of BOWMAN, and the wall of the blood vessels and capillaries were not destroyed, the parenchym of the kidney could then regenerate. PONFICK pointed out a phenomenon of regeneration of the uriniferous tubules in the medullar portion in a case in which the hydronephrotic atrophy was not so remarkable. ENDERLEN also described fine regenerated convoluted tubules in the deep layer of the cortical portion in a case in which the proximal convoluted portion had in general fallen into a striking collapse.

Any feature which suggests without doubt a regenerative process was not observed throughout my experiment. In a case in which 75 days elapsed after operation, we find some structures which present a somewhat normal appearance and may be mistaken at a glance as new formations among the highly altered structures in the labyrinths. But this is probably an intact region which has not yet been affected by the degenerative process. As the degenerative process in hydronephrosis following a sudden ureteral blockade is progressive, though slow, in contrast to that of the intermittent hydronephrosis, it is reasonable to suppose that we should find no such feature of regeneration, though further special observation is needed in order to study the regeneration accurately.

The recovery of the function. In the kidney in which the urinal passage is interrupted, it is very important and interesting to determine how long it can continue its function, or to what period it maintains the ability to recover its function.

There are not a few investigators who made morphological observations on this problem, by the application of vital staining. Those who observed a decrease or an abolition of the secretion of the dye-stuff in a relatively early stadium are SCHLECHT, PARI, KAWASOE, KIYONO and KIKUCHI, and OSHIMA. Those who affirmed the relatively long preservation of the excreting function as tested with staining are SUZUKI, TARUMI and TOYA, HOZUMI, and KITANI. BOETZEL ('14) observed in the rabbit that on the sixth day after the operation the the function of the excreting dye-stuff ceased completely; that on the 30th day no pigment granules were seen in the cells of the proximal

convoluted portion; that from the 21st to 30th day, when the ligature was removed, the kidney could recover the excreting function, while on the fortieth day the atrophic process was so advanced that the excreting function was not restored, though the ureteral ligature was removed. KITANI ('25) affirmed that the excretion of the dye-stuff was still remarkably strong 12–15 weeks after the operation, and that after 48 weeks the existence of the pigment was still proved in the endothelium of glomeruli. Then he concluded that if it were allowed that all the dye-stuff were excreted through the glomeruli alone, it could at least be said that until this period many glomeruli still allowed the blood to flow. As the dye-stuff can remain in the epithelium for a long time, as SUZUKI mentioned, and observations differ according to the animals, KITANI does not lay much weight on his own conclusion.

In the present investigation, the following facts were observed. In the case which extended over 200 or 237 days, the glomerulus still maintained to some extent its original form as well as some blood in its capillary loops, and even in the case which extended over the longest interval of 375 days the form of the glomerulus was still discernible in the midst of shrinkage, though no more fresh blood was observable in it. In the parenchym, which now takes a membranous and capsular form as in the case just mentioned, fresh blood is still fairly observable in other structures than in the glomeruli, and the fluid stagnated in the pelvis is yet neither much reduced in its amount nor increased in its density. As is also obvious from the histo-anatomical observations, we may be justified to suppose that the glomeruli perform a physiological function to some extent in such an advanced stage as in the long continued experiments mentioned above. Therefore, if causes such as an increased internal pressure in the pelvis, which lead to a functional insufficiency or to an atrophy, are removed, or in other words, the ureteral ligature is removed for reestablishing the normal urinary passage, the glomerular unit system may probably recover its excreting function to a certain degree, even after the pathological alterations have advanced to a considerable extent.

Indeed, KITANI noted the existence of the dye-stuff even 48 weeks after the ligature, indicating the strong resistance of the kidney tissue

under extreme advanced condition on one hand and probable maintenance of ability to recover its function even after the kidney showed considerable alteration on the other.

3. Changes in the Weight and Volume of the Obstructed Kidneys.

The total weight (renal parenchym plus the stagnant pelvic fluid) of the obstructed kidneys shows in general a remarkable increase in comparison with the normal and their sister kidneys throughout the experiment.

As is obvious from Table X and Figs. 10, 11 and 12, in the first stadium the obstructed kidney is about 3 times the normal in the total weight, and thereby it is 1.3 times the normal in length, 1.5 times in breadth and 1.9 times in thickness, when each average value in length, breadth and thickness of the normal kidneys is taken as a unit respectively. Similarly when each value in length, breadth and thickness of the enlarged sister organs of the same individuals is also taken as a unit, the obstructed organ is 1.2 times the sister organ in length, 1.3 times in breadth and 1.9 times in thickness in the first stadium. When the productive value of the three axes in the normal and enlarged sister kidneys is taken as a unit respectively, the apparent volume of the obstructed organ is 3.7 times the normal and about 3 times the sister organ in the first stadium.

In the second stadium the obstructed kidney is about 2.6 times the normal in the total weight, and it is 1.3 times the normal and 1.1 times the sister organ in length, 1.5 times the normal and 1.2 times the sister organ in breadth, and 1.8 times the normal and 1.5 times the sister organ in thickness. The apparent volume of the obstructed kidney in this stadium is 3.5 times the normal and 2.0 times the sister organ.

In the third stadium the obstructed kidney is 1.3 times the normal in the total weight, and it is almost the same as the normal in length, while it is 0.9 times the sister organ in length, and it is 1.1 times the normal and 0.9 times the sister organ in breadth, and it is 1.3 times the normal and 1.1 times the sister organ in thickness. The resulting volume of the obstructed kidney is 1.3 times the normal and about 0.9 times the hypertrophied enlarged sister kidney in the

TABLE X.

Relation among the lengths of the normal, hypertrophied and obstructed kidneys.

Stadium	Serial No.	Days after oper.	Bodyweight (g.)	Increase in weight of kidney (%) R.	Increase in weight of kidney (%) L.	Absolute values in length (mm.) R.	length L.	breadth R.	breadth L.	thickness R.	thickness L.	Relative values in length R/N	length L/N	length L/R	breadth (mm.) R/N	breadth L/N	breadth L/R	thickness R/N	thickness L/N	thickness L/R
I.	44	4	1770	28.3	41.6	31	35	22	19	12	13	1.10	1.25	1.13	1.15	1.00	0.86	1.09	1.18	1.08
	32	5	1180	70.0	200.0	30	35	20	30	09	22	1.07	1.25	1.17	1.05	1.57	1.50	0.81	2.00	2.44
	31	6	1305	54.6	113.0	32	35	18	23	11	20	1.17	1.25	1.09	0.94	1.21	1.25	1.36	1.81	1.33
	7	7	1640	8.9	101.7	29	34	19	25	11	20	1.03	1.21	1.17	1.00	1.32	1.30	1.00	1.81	1.81
	25	8	1430	20.4	206.2	25	34	17	28	10	23	0.89	1.21	1.36	0.89	1.47	1.60	0.91	2.09	2.30
	51	9	1360	69.6	128.2	32	33	22	25	12	17	1.14	1.17	1.03	1.15	1.32	1.13	1.09	1.54	1.41
	47	10	1780	47.6	162.3	35	37	23	25	09	14	1.25	1.32	1.05	1.21	1.32	1.03	0.81	1.26	1.55
	5	11	1435	91.8	206.2	34	39	24	30	11	20	1.21	1.39	1.14	1.26	1.57	1.24	1.00	1.81	1.81
	50	13	1020	100.0	200.0	32	33	23	29	14	17	1.14	1.17	1.03	1.21	1.52	1.26	1.27	1.54	1.21
	10	14	1245	54.7	351.6	25	40	21	30	09	28	0.89	1.42	1.60	1.11	1.57	1.43	0.81	2.54	3.01
	19	17	1295	46.3	185.6	23	35	19	30	09	25	0.82	1.25	1.50	1.00	1.57	1.57	0.81	2.27	2.77
	33	27	1665	75.4	510.0	35	51	24	45	17	35	1.25	1.82	1.45	1.26	2.36	1.85	1.54	3.18	2.06
Average			1418	55.6	200.5	30	37	21	28	12	21	1.08	1.33	1.22	1.12	1.48	1.34	1.01	1.92	1.88
II.	46	30	1940	24.2	28.7	34	34	25	27	16	18	1.21	1.21	1.00	1.32	1.42	1.07	1.45	1.63	1.13
	43	40	1550	22.7	73.6	28	27	20	20	08	15	1.00	0.96	0.95	1.05	1.05	1.00	0.72	1.36	1.87
	4	45	1513	47.0	123.5	30	34	22	24	10	15	1.07	1.21	1.13	1.15	1.26	1.10	0.91	1.36	1.50
	28	70	2020	23.7	421.8	32	47	22	35	14	33	1.14	1.67	1.47	1.15	1.84	1.59	1.27	3.00	2.35
	23	75	2095	17.0	245.6	30	45	23	35	15	25	1.07	1.60	1.50	1.21	1.84	1.52	1.36	2.27	1.69
	27	85	2170	87.0	21.6	40	32	27	23	17	15	1.42	1.14	0.80	1.94	1.21	0.85	1.54	1.36	0.88
	40	105	2280	52.8	183.3	36	40	26	29	15	20	1.28	1.43	1.11	1.36	1.52	1.11	1.36	1.81	1.33
Average			1938	39.3	157.0	33	37	23	28	13	20	1.18	1.32	1.13	1.31	1.45	1.17	1.23	1.82	1.53
III.	39	120	2000	2.9	-25.0	28	22	23	18	10	14	1.00	0.78	0.78	1.21	0.94	1.11	0.91	1.27	1.33
	24	124	1940	66.6	51.4	37	33	27	22	14	17	1.32	1.17	0.88	1.42	1.15	0.81	1.27	1.54	1.22
	30	127	2060	29.4	41.2	33	31	23	26	13	14	1.17	1.10	0.93	1.21	1.36	1.12	1.18	1.27	1.07
	36	133	2550	4.7	- 6.9	33	25	20	20	15	15	1.17	0.89	0.75	1.05	1.05	1.00	1.36	1.36	1.00
	37	138	2220	-6.7	-26.7	30	28	22	15	12	11	1.07	1.00	0.93	1.15	0.78	0.68	1.09	1.00	0.91
	35	140	2150	23.3	2.7	31	26	25	21	10	10	1.10	0.92	0.84	1.32	1.11	0.84	0.91	0.91	1.00
	34	148	1820	11.2	111.3	28	33	20	23	14	17	1.00	1.17	1.16	1.05	1.21	1.15	1.27	1.54	1.21
	3	163	2360	30.0	87.5	31	35	25	30	11	23	1.10	1.25	1.12	1.32	1.57	1.20	1.00	2.09	2.10
	29	173	1750	78.3	- 38.3	37	23	25	18	12	05	1.32	0.82	0.62	1.32	0.94	0.70	1.09	0.45	0.42
	20	200	2060	21.4	52.8	22	25	20	21	15	20	0.78	0.89	1.13	1.05	1.11	1.05	1.36	1.81	1.33
	6	237	1590	46.8	-24.1	30	22	20	16	15	10	1.11	0.78	0.73	1.05	0.78	0.75	1.36	0.91	0.66
	2	375	1680	76.4	81.3	37	35	26	30	17	21	1.32	1.25	0.94	1.36	1.57	1.15	1.54	1.91	1.23
Average			2014	31.6	25.5	31	28	23	22	13	15	1.12	0.99	0.89	1.21	1.13	0.92	1.19	1.34	1.12
Total average			1766	42.6	128.0	31	33	22	26	13	18	1.12	1.18	1.07	1.19	1.33	1.14	1.14	1.67	1.52

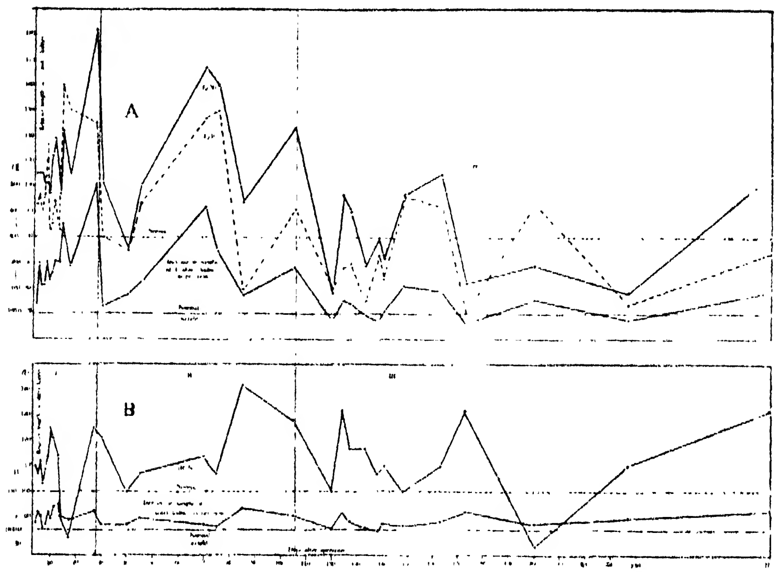

Fig. 10. Showing relation between the length and weight of the kidneys (Constructed from Table X.)

A. L/N — relative length of the obstructed to normal kidneys.

L/R — relative length of the obstructed to the sister kidneys.

B. R/N — relative length of the sister kidneys to the normal.

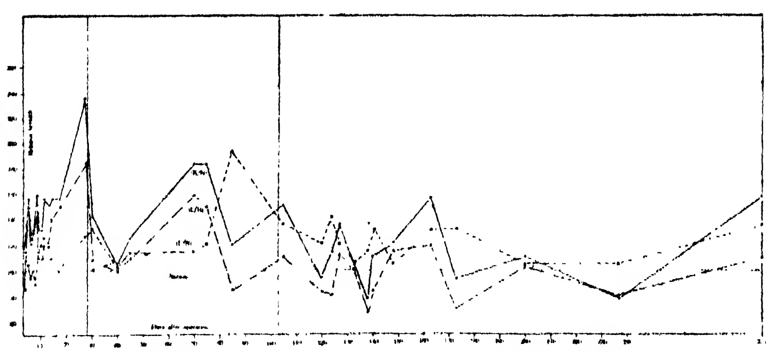

Fig. 11. Showing relation in the breadth of the kidneys. (Construcied from Table X.)

L/N — relative breadth of the obstructed to the normal kidneys.

L/R — relative breadth of the obstructed to the sister kidneys.

R/N — relative breadth of the sister kidneys to the normal.

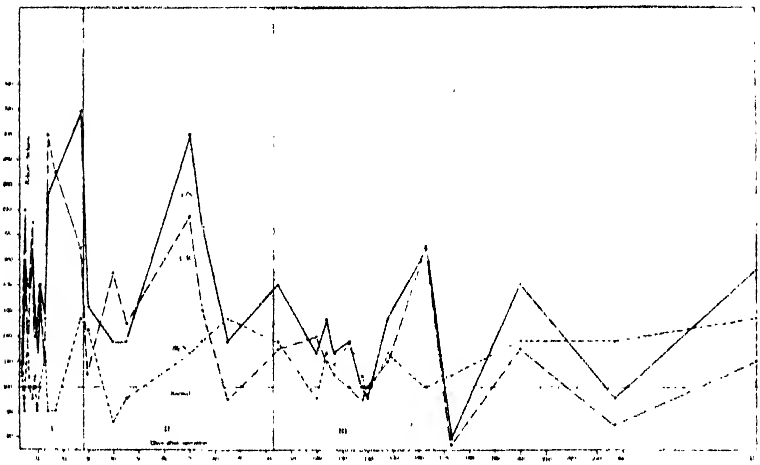

Fig. 12. Showing relation in the thickness of the kidneys. (Constructed from Table X.)

L/N — relative thickness of the obstructed to the normal kidneys.
L/R — relative thickness of the obstructed to the sister kidney.
R/N — relative thickness of the sister kidneys to the normal.

last stadium.

On the total average throughout the experiment the obstructed kidney is still 2.3 times the normal in weight, and is 1.2 times the normal and 1.1 times the sister organ in length, 1.3 time the normal and 1.1 times the sister organ in breadth, and 1.7 times the normal and 1.5 times the sister kidney in thickness. On the average the volume calculated for the obstructed kidney is about 2.7 times the normal and 1.8 times the hypertrophied sister kidney, while that for the latter is still 1.5 times the normal.

In short, the obstructed kidneys show a somewhat more remarkable increase in all three axes than those of the normal and enlarged hypertrophied sister organs in the first stadium, while in the second stadium they show a tendency toward decrease in every axis. In the third stadium they show a far more remarkable decrease in longitudinal and transversal axes, maintaining still some increase in the dorso-ventral axis and thus giving a globular form.

Such a remarkable increase in the volume and weight of the obstructed kidney is due mainly to an enormous increase in the amount of the fluid accumulated in the renal pelvis. To eliminate this effect

in computation of relative values the weight of the remaining parenchym was therefore estimated separately from the stagnant pelvic fluid.

In the period extending from the first to the 27th day the weight of the remaining parenchym not only always surpasses remarkably the weight of the normal, but also exceeds the weight of the sister kidney, and the pelvic fluid accumulated. From such a relation in the weights, the period is called the first stadium, as was already described.

In the following period, which extends from the 28th to the 105th day, the weight of the remaining parenchym can be considered almost equal to the normal, and the period is called the second stadium. In the next period, which extends from the 106th to the 375th day, or to the end of the experiment, the condition of the weights is wholly reversed from that in the first stadium. That is, the remaining parenchym shows a continual decrease and is always lighter than the weights of the normal and the hypertrophied sister kidney, and the pelvic fluid, and this period is called the third stadium. Especially in a case which survived 375 days and which was the last example of the experiment, the renal parenchym had lost about 70% of its original weight.

As to the period, in which the total weight of the obstructed kidney reaches the maximum, it is earlier in my study than is reported by some investigators such as PONFICK, WINKLER, etc.

In the experiment of PONFICK on the rabbit, the weight reached its maximum on the thirty-seventh day after operation, showing an increase of 78.2%, and thereafter reduced step by step, and by the seventh month it had decreased so much that it was only one fifth of the weight of the sister kidney. WINKLER examined the relation of the weight of the kidneys in the rabbit, as had PONFICK, and observed a remarkable increase in the weights of the parenchym and the pelvic fluid on the thirtieth day after operation, and an increase in both these weights little by little during several days afterwards, showing the maximum on the forty-fifth day, and decreasing their value afterwards.

KAWASOE also observed in the rabbit that in the complete obstruction of one side of the ureter the pelvic fluid increased very gradually until the seventieth day after the ligature, while the weight of the

parenchym reached its maximum on the fourteenth day, thereafter decreasing rather gradually.

OSHIMA, working on the rabbit, saw that the weight increased abruptly for a day or two, but afterwards increased relatively gradually, and reached the maximum on the twenty-fifth day. TARUMI and TOYA observed that on the 7–9th day after operation the weight of the obstructed kidney became twice as great as that of the sister organ, and thrice as great on the 25th day, but thereafter was always decreasing, and on the 57th day the weight of the right and left organs became equal, that of the obstructed side thereafter decreasing step by step, and on the 213th day it was only 1/4 of the weight of the sister kidney. HOZUMI studied on the rabbit, cat, dog, etc. and pointed out that the obstructed kidney increased rapidly in weight on the second or third day; that on the 7–14th day the weight became double that of the sister kidney, and on the 22nd day five times as great, afterwards decreasing, so that on the 65th day both were equal; and that in one case on the 216th day the weight of the obstructed kidney was still thrice as great as that of the sister kidney.

Amount of the stagnant pelvic fluid. On looking over my examples, it will be seen that the fluid accumulated in the pelvis increased gradually in the early period in accordance with the increase in the weight of the obstructed kidney, namely from 4 cc. on the 8th day to 15 cc. on the 27th day or the end of the first stadium. It measured 30 cc. on the 70th day or at about the middle of the second stadium, which was the maximum, therefter decreasing to 10 cc. on the 105th day or at the end of the second stadium, and afterwards showed fluctuation, on the 375th day or at the end of the third stadium having decreased to 7 cc.

As is seen from the above description, there is shown remarkable fluctuation in the amount of the pelvic fluid, though at the same time we can see a certain regularity in it, that is, it is least in the first stadium, showing 3.5 cc, while it is greatest in the second stadium, amounting to 11.2 cc., and in the third stadium it shows some decrease, amounting to 5.1 cc. on the average. On the total average throughout the experiment it amounts to 6.1 cc.

Findings of my cases agree well with these of KAWASOE, but the increase in the pelvic fluid occurs somewhat later than reported by

WINKLER, who observed that the amount of the pelvic fluid reached the maximum on the 30th day after operation and thereafter decreased gradually. On the contrary, in my cases, the amount of the pelvic fluid reached the maximum remarkably earlier than in the cases of some investigators, for instance, OSHIMA stated that the amount of the pelvic fluid increased gradually after operation and it showed 10 cc. on the 119th day, and was still 10 cc. on the 208th day or at the end of his experiment, showing no increase.

TARUMI and TOYA reported that until the 105th day it showed gradual increase and measured 40 cc. then decreased gradually, and still measured 5 cc. on the 213th day or at the end of his experiment. KAWASOE asserted that until the 70th day it showed a gradual increase.

Now I shall pursue the following question as to what process and mechanism the increase in the volume and weight of the obstructed organ was caused, and how the compensatory hypertrophy of the sister organ was brought about.

Some interpretations on the increase in weight and volume of the obstructed kidney. It has already been described how the kidney, whose ureter is suddenly obstructed and its function interrupted, undergoes progressive hydronephrotic alteration, and the affected parenchym swells and increases its volume and weight for a relatively long period.

Earlier investigators believed that they could easily discover the solution to the question, by what process such an increase is brought about, and that the phenomenon itself was not so remarkable and was rather temporary. They ascribed it to the excessive early impregnation in the interstitium. This consideration is more rightly recognized microscopically than macroscopically, for the diffuse impregnation in the interstitium would be almost all lost during the procedure of the microscopical preparation, and remarkable sponginess thus produced in the parenchym obviously points to the truth of the above statement.

CONHEIM did not overlook the fact that this condition was accompanied by oedematous appearance, but he considered it rather temporary, and as being caused by the compression of the blood vessels, especially the veins in the hilum, and by the dilatation of the renal

pelvis caused by the stagnated fluid. PONFICK observed in his experiment that after recovering from the acute oedema, the volume of the obstructed kidney increased for a long while, and pointed out as its cause the hemorrhagic exsudative process in the parenchym, namely, that the protein was discharged in the uriniferous tubules, stagnated and coagulated, and the transudate from the blood vessels of the renal pelvis, and the secretion from the mucous membrane of the pelvis were added. In short, these conditions led to the dilatation of the tubular system and then to the serous impregnation of the interstitium, thus seeming to induce the increase in the volume and weight of the organ in the early stadium.

HENKE and LUBARSCH saw that in the kidney, as in other organs, stagnation caused by mechanical and toxic process induced oedema, namely, the acute urinary stagnation led to oedema of the kidney and to the extention of the interstitium. KAWASOE ascribed the cause of the increase in volume to the increase of the fluid content in the uriniferous tubules. OSHIMA asserted that the increase of the renal parenchym was due not only to the fluid content in the tubules, but also to the proliferation of the interstitial tissue, which was rich in the cellular elements. HOZUMI stated that as the increase in the weight was not proportional to the fluid content of the tubules, the principal cause of the increase was probably due to the proliferation of the interstitium.

As already described above, there are many factors causing the increase in volume and weight of the parenchym in the obstructed kidney, but we can point out at least the following two factors as the chief ones. (1) The increase owing to stagnant pelvic fluid which consists of excretion from the glomerular unite system, and transudate from the vascular system, and (2) the so-called oedematous process, namely, the impregnation of the spaces in the parenchym or infiltration of the tissue. As to the oedematous process, the following factors can be pointed out.

Oedema is caused by stasis in the veins. Why oedema is brought about by stasis of the venous blood is that plasma is much pressed out of the vessel by the rise of the blood pressure in the vessel and that at the same time the blood and lymph vessels are pressed by the surrounding tissues, which are infiltrated by this plasma fluid and

become oedematous. It thus causes itself not to be absorbed. According to YAMAGIWA the local oedema can be considered as almost wholly due to the local stasis of venous blood. LANDERER ('84) ascribed easy transudation of plasma from blood vessels to the decrease of elasticity in the surrounding tissues and external pressure, when rise of the blood pressure caused by stasis continued for a long time. HAMBURGER ('04) concluded that the stasis in capillaries induces a stagnation of metabolic products, stimulates the endothelium, and raises the secretory ability of lymph, thus finally leading to oedema.

The protein content of the oedematous transudate caused by stasis is, as a rule, small, but it increases when the stasis advances and blood pressure rises (SENATOR). Moreover, the transudate gains lymphocytes (K. ZIEGLER) and red blood corpuscles, increasing their contents with the degree of stasis.

As was already considered by COHNHEIM, LICHTHEIM, THOMA etc., the alteration of the walls of the blood vessels caused by the continued stasis and anaemia increases the permeability of the endothelium, leading to oedema of the surrounding tissues. Moreover, the paralysis or irritation of the vaso-motor nerve brings about the increase of permeability or secretory ability of the capillaries. But the character of the transudate in this case is a little different from that caused by stasis, namely, the oedema fluid from inflammatory cause contains more protein and more lymph corpuscles, and posseses heightened coagulability. Meanwhile, hydraemical oedema fluid lacks coagulability, but gains much more sodium chloride.

From the standpoint of colloid chemistry, deviating wholly from previous views, MARTIN H. FISCHER ('10) ascribed the cause of oedema not to the vascular system, but to the tissue itself. After many experiments he reached the conviction that oedema is a consequence of swelling or increased hydration capacity of the tissue colloid, and that they are induced by acids, which are produced in the tissue on account of the interruption of oxidising processes or the want of oxygen. ARAKI and ZILLESSEN also pointed out that the want of oxygen in the tissue produces an acid in a considerable amount as its result. A certain author maintained that a substance, which is produced in kidney diseases and interrupts the oxidising process, acts an important part. Furthermore, SPIRO observed that gelatine absorbes 3–4 times

more water in solution of N/40 HCl or N/36 KCH than in pure water owing to the hydrogen ion concentration. The effect of H-ion upon swelling is very remarkable. STRASSBURG and EWALD actually found that the CO_2 content of oedema fluid is far greater than that of venous blood. However, though it awakened great sensations, the hypothesis of MARTIN H. FISCHER raised many objections. We describe here some of the objections briefly. PINCUSSOHN observed that the kidney, spleen, liver, etc., swell less in acid solution than in pure water, and that in acid solution and water the cortex swells somewhat more strongly than the medulla of the kidney. LUBARSCH pointed out that there is an essential difference in nephro-oedema according to whether the renal veins or the renal arteries are pinched, though the apparent feature is the same in both cases. The effect is reversible in the former case, but it is irreversible in the latter case, when the pinch of the vessels lasts three hours. G. MOORE denied the formation of acid in tissue, for he could not prove by means of colour indicator the existence of any acid in the kidney or lymph of a rabbit, to which hydrochloric acid had been injected previously into the muscles, by which procedure oedema is induced, according to FISCHER.

The next opposition was offered by some pathologists, such as MARCHAND, KLEMENSIEWICZ, SCHADE, etc., who asserted that what was described by FISCHER was not a true oedema, stating that the connective tissue, the chief locality for oedema, shows apparent swelling or contraction due to acid or salt, as fibrin, at a glance, but under microscopical examination the feature of the tissue which has swollen by acid is wholly different from that of the true oedematous swelling. Namely, the tissue which is swollen by acid shows strong hyaline or amyloid degeneration. In the acid solution the fiber mass became swollen chiefly, while in oedema the swelling lies on the outside of the fibrils. FISCHER does not distinguish the swelling of the plotoplasmatic substance from the turgor of the whole tissue.

For in the oedema of the connective tissue the serous fluid accumulates chiefly in the meshes of the tissue, but not in the protoplasm itself, so the increase of ability of water absorption in the cells is not an essential motive of oedema formation.

F. VOLHARD also denied FISCHER's theory and insisted that FISCHER conceived the condition of the combination between tissue and water,

which would be called at best intracellular oedema or prae-oedema, as an oedema caused by swelling of tissue itself, for as the true oedema is a process in which free water accumulates in the meshes or interstices of the tissue, it would naturally come to the opposite conclusion. The increase of the hydrophily or the hydration capacity of tissue colloid induced the decrease of oedema, contrary to FISCHER's observation, and it must hinder the oedema formation or the accumulation of water which was free but did not combine with colloid. VOLHARD ascribed the origin of oedema to the changes of the wall of the vascular system, and pointed out that oedema did not depend upon the hydrophily of the tissue colloid.

As is obvious from the above description, there seems to be two chief opinions as to the oedematous process, (1) changes in the vascular system (COHNHEIM, VOLHARD etc.) and (2) changes in the hydration capacity of the tissue colloid (FISCHER etc.), though it is admitted by almost all workers that the increase in weight and volume of the parenchym, whose ureter is obstructed, is due chiefly to an oedematous condition.

Considering from my own results, it is seen that the observations of COHNHEIM and his supporters are right to some extent. For we find that the ureteral obstruction leads first to stagnation of the urinary fluid and increase of the internal pressure of the organ. At the same time, it induces disturbance of the blood circulation, especially stasis of the venous blood and then alteration of the walls of the vessels, allowing an increased permeability to them. Moreover, secretion from mucous membrane and transudate from the blood vessels of the renal pelvis and ureter may be able to join partly to the fluid from glomeruli which function maintain considerably good for a long while.

The fluid thus produced infiltrates into the tissue, pressing upon the surrounding tissue. The transportation or absorption of the fluid through the vascular system is thus interrupted stronger, the impregnation of the parenchym or oedema becomes stronger, accompaning a decrease of the elasticity of the tissue.

At the same time, we can partially support FISCHER's view from our own observation. As the H-ion concentration of the tissue is equal to that of the fluid which immerses the tissue (KATO), in my

case the pH of the renal parenchym would be 5.58–6.72, showing an acid reaction, in the first stadium, for the pH of the pelvic fluid had such value. Therefore, it is probable that the acid increases the hydration capacity or swelling ability of the tissue colloid to some extent, thus leading to oedema, as FISCHER believes.

I agree with FISCHER, in stating that the urea seems to act a part in increasing the water-absorbing power of the tissue in the first stadium, in which the fluid content is still urinous.

Furthermore, from the histo-anatomical observation of the spongy appearance of the parenchym, is anticipated what significance the serous impregnation of the parenchym has upon the increase of weight and volume of the organ. And we observe that the water content of the parenchym is greatest in the first stadium, in which the weight and volume of the organ are greatest, showing a strong spongy appearance. Therefore, we see what an important part water plays in the increase of weight and volume of the organ in such a case as this.

4. Compensatory Hypertrophy in the Sister Kidneys.

It is a well known fact that when one of the kidneys cannot fulfil its function due to some disorder, such as ureteral obstruction, the sister organ, putting its potential ability into action at once, begins to compensate for the work of the organ to avoid a disturbance of general metabolism. This excessive function together with the hypertrophy of the organ should be considered as an important reaction of organisms.

The weight as well as the volume of the sister organ of the obstructed kidney shows, of course, a gradual increase in accordance with the days elapsed, owing probably to compensatory hypertrophy coused by excessive function, but it is worth while to note that, though the sister kidney thus performs almost twice the normal work to compensate for the functional insufficiency of the obstructed kidney and increases also its weight and volume, they seem never to reach twice the normal, as is observed also by some previous authors.

In my cases the sister kidney is 1.6 times the normal in weight, and it is 1.1 times the normal in length and breadth and almost equal to the normal in thickness in the first stadium, when each average

value in length, breadth and thickness of the normal kidneys is taken as a unit in these cases as in the preceding chapter. It is 1.2 times the volume, when the productive value of the three axes in the normal kidney is taken as a unit, as is in the obstructed kidney. In the second stadium it is about 1.4 times the normal in weight and 1.9 time in volume, and 1.2 times in length and thickness, and 1.3 times in breadth. In the third stadium it is about 1.3 times in weight and 1.6 times in volume, and 1.1 times in length, 1.2 times in breadth and thickness. On the total average it is about 1.4 times the normal in weight and volume, and 1.1 times in length and thickness, and 1.2 times in breadth as is seen from Table X and Figs. 10, 11 and 12.

From the above factors we may anticipate that in the enlargement of the kidney due to compensatory hypertrophy, the organ increases gradually in all direction to the end of the second stadium, showing especially a stronger increase in the transversal and dorso-ventral axes. Afterwards, however, it shows a tendency of gradual decrease, and this is probably because the organ, which was forced to an excessive function owing to the sudden functional insufficiency of the sister kidney and showed an anormal increase in its axes, gains an ability of adapting itself to the increased function with smaller volume.

This is also probable because all the parts of the kidney may not enlarge in the same degree, but the glomeruli and convoluted portions, which perform the excretive function, may have shown the highest degree of responsive enlargement.

Most investigators agree that the remaining or the sister kidney performs a compensatory enlargement in such a case as the ureteral obstruction, but as to the portions enlarged, or the mechanism of the enlargement, their interpretations do not always agree. In regard to the portions enlarged, some insist upon the fact that they observed hypertrophy in sensu stricto of the glomeruli, while some others found proliferation of both glomeruli and tubules. With regard to the mechanism, some maintain that the enlargement is a mere hypertrophy, some others claim it to be a mere hyperplasia, while still others persist on the combined result of both hypertrophy and hyperplasia.

According to RIBBERT ('82), NOTHNAGEL ('96), EPPINGER and WAGNER the enlargement of the sister kidney is due to the hypertrophy of glomeruli and the epithelium of the convoluted portions; according

to the conclusions of GUDDEN ('76) and YAMAGIWA ('89) it is caused above all by the hypertrophy of glomeruli. Among those who ascribed it entirely to hyperplasia are SIMON ('71), ROSENSTEIN ('71) and BEUMER ('78), and among those who maintained the combined action of both hypertrophy and hyperplasia are LEICHTENSTERN ('81) and GUTTMANN ('83).

GALEOTTI and VILLA-SANTA ('02) examined the number and size of glomeruli and convoluted portions after unilateral nephrectomy in the rabbit, and found that almost double the normal function of the remaining kidney was performed by hyperplasia of the glomeruli in young animals, but by hypertrophy of them in old animals. Lately ARATAKI ('25) counted actually the total number of glomeruli in albino rats after unilateral nephrectomy and found that the number remained almost constant and that the enlargement of the organ was chiefly due to hypertrophy of the glomerular system and to hyperplasia of the supporting tissue.

ECKARDT ('88) noticed hypertrophy as well as hyperplasia of the glomeruli and convoluted portions in congenital defect of the kidney, but never saw hyperplasia in postnatal defect. According to NOTHNAGEL and SACERDOTTI, an increase of an adequate stimulation which causes the specific action of the organ is required for the increase of the function of an organ. So that, in my cases of ureteral obstruction, surplus of substances composing the urine may circulate in the blood and stimulate the specific elements of the remaining kidney, which would respond with the increase of its function accompanied by the increase of its volume and weight.

ENDERLEN ('04) and NAKANO ('22) examined the change in the remaining kidney by vital staining, and in the 24th hour after operation saw a change in ALTMANN's granule in the convoluted portions, and on the fifth day after operation the change in the epithelium of the convoluted portions reached the maximum, but on the sixth day (ENDERLEN) or on the 12th day (NAKANO) the change recovered gradually. Concerning the cause of the enlargement, I have shown already that the views of the investigators differ so widely that it is difficult at present to state the general tendency of current opinions. So far as my own observations are concerned, I am inclined to believe that this enlargement of the sister kidney must be resulted from both

hypertrophy in sensu stricto and hyperplasia from the facts: (1) the diameter of the glomeruli show actually considerable increase, (2) the convoluted portions show conspicuously the more convoluted appearance than before as if the entire tubules were elongated owing either to the increase in cell size or to the cell number or both, (3) proliferation of the interstitial tissue, (4) strongly congested and dilated blood vessels and capillaries, which suggests an increased activity,. and in fact in dissection the art. renalis shows a diameter almost twice the normal.

VILLA-SANTA estimated the area of the glomeruli in the microscopical field, and compared the relative area of the hypertrophied kidney with that of the normal, and found the ratio of hypertrophied to normal to be 1.82 in the dog and 2.09 in the rabbit. Similar computation gives the value of 1.2 or 1.3 for the hypertrophied kidney in my experiment.

The statements mentioned above are histological considerations in the compensatory hypertrophied kidney. As to the changes in chemical composition in the hypertrophied kidney, we can point out briefly the following facts. The water content of the obstructed kidney is greatest, that of the hypertrophied organ is intermediate and that of the normal one is smallest. When the above fact is considered correlatively with the histological findings of these organs, we find that the water content is almost concordant with the degree of the spongy appearance of the tissue of the organs in section, probably because of the filling of the meches of the parenchym with substance of high water content. The contents of organic substance, inorganic substance and chlorine in the fresh materials are greatest in the normal kidney, contrary to the water content. But when they are expressed in percentage of dry substance, they are greatest in the obstructed kidneys and smallest in the hypertrophied kidney. This may be due to the fact that these substances are not liable to accumulation on account of the increased metabolism of the cells caused by increased function in the latter.

As to the content of the total nitrogen, it is greatest in the normal kidney, that of the hypertrophied sister organ lies next, and that of the obstructed organ is smallest, on the total average. For in the hypertrophied sister organ, the organ is supplied with much more blood owing to its excessive function, and becomes more succulent.

We actually find that the water content of the sister organ is somewhat greater than that of the normal. In the obstructed kidney both blood supply and urine production are strongly interrupted with its ureteral obstruction on the one hand, and on the other organ becomes oedematous and much more succulent than the other organs as is shown by the actual water content, and finally it is disintegrated. But the disintegration products of nitrogen compounds in the organ pass partly over the pelvic fluid and partly over the blood circulation for absorption, and this is probably because the total N content is the least in the obstructed kidney.

Fatty substances. The content of the fatty substances is also greatest in the normal organ, intermediate in the hypertrophied kidney, and smallest in the obstructed organ. The smallest content in the last is probably owing to the disturbance of nutrition caused by the disturbance of the blood supply.

5. Changes in Blood After Operation.

Although for the functional examination of the kidney, it is very important to know the change in blood, especially to determine various substances in the blood, it is not always easy to know the changes completely with a small sample of blood. The experiment tells us that the amount of protein which is isolated from the blood varies more or less acording to the methods employed. We even assume that this variation was removed by using the same technique throughout, but we must admit that there is another variation to the individual.

Since BRIGHT ('36) recognized the fact of the presence of nitrogen-containing substances in the waste products which stagnated in the blood of nephrotic patients, such conditions have been reexamined by a good many scholars, such a ASCOLI, STRAUSS, MÜLLER, OBERMEYER, etc.

STRAUSS considered that the determination of non-protein nitrogen in blood was most certain and important for deciding the degree of the excreting function of the kidney. He produced experimentally uran and chrom nephritis and found 250–290 mg. of non-protein nitrogen in 100 cc. of blood in the uran nephritis on the 4–5th day after injection, but in chrom nephritis he did not observe any increase of non-protein nitrogen. According to his observation, non-protein

nitrogen seems to have increased in destruction of glomeruli or uran nephritis, while in the destruction of tubules or chrom nephritis it does not show any remarkable increase.

According to ICHIMATSU ('21), the content of urea nitrogen in blood plasma is 35 mg. per 100 cc, and that of non-protein nitrogen under 55 mg. According to the result of FURUYA ('22), the content of urea nitrogen in a one-kidneyed rabbit is 55 mg., the content of sodium chloride in a normal rabbit 586 mg. in 100 cc. of blood plasma, but no apparent difference is seen in a one-kidneyed animal in this regard.

TABLE XI.

Findings in blood before operation and at the end of experiment. (mg. per 100 cc.)

Number of rabbit	Days after operation	Non protein N.		Urea N.		NaCl	
		before operation	at the end of experiment	before operation	at the end of experiment	before operation	at the end of experiment
31	6	63	60	56	—	385	370
7	7	62	80	58	—	354	400
25	8	54	—	—	—	215	—
47	10	84	90	50	70	350	300
5	11	76	90	72	—	500	—
10	14	80	—	60	80	282	400
19	17	50	70	50	—	285	—
33	27	60	78	60	—	—	340
4	45	60	90	—	70	500	—
28	70	85	75	48	70	—	—
23	75	63	90		—	234	—
27	85	68	59	—	—	350	—
40	105	90	83	—	—	200	—
39	120	60	70	20	40	321	—
24	124	51	96	—	—	204	—
30	127	80	—	35	50	364	—
35	140	70	—	—	—	322	—
34	148	84	100	50	70	200	—
29	173	61	75	—	—	392	—
20	200	58	90	—	—	—	—
6	237	42	70	20	30	400	500
2	375	70	100	50	50	—	450
Average		67	81	48	59	336	395

Observing from the above table of my experiment, I come to the conclusion that, as to the non-protein nitrogen, it is 67 mg. in 100 cc. of blood before operation and 81 mg. after operation, showing a slight increase in the content. As to the content of urea nitrogen, it amounts 48 mg. before operation, and 59 mg. after operation, showing an increase. Concerning the content of sodium chloride, it amounts to 336 mg. before operation and 395 mg. after operation, showing a considerable increase but deviating from the observation of FURUYA. As a whole, the result of my own observation shows some deviation in the amount of these substances mentioned above from those of some others. But so far as my own observations are concerned, the substances mentioned are almost greater after operation than before operation, leaving so much end products of nitrogen contained and sodium chloride in the blood. This is probably because the hypertrophied sister kidney is not yet able to eliminate the metabolic products which accumulate in the blood.

6. Changes in Urine After Operation.

FRISCH and ZUCKERKANDL examined in man the daily amount of urine in many cases of the unilateral extirpation of the kidney, and observed that the amount diminished to 150–300 cc., namely about 1/10–1/5 of the normal value, on the first day after operation, thereafter increasing gradually, and on the 12th day it was restored to the normal value. Then, sometimes polyuria occurred, continuing for several weeks. SCHILLING reported that in a case of a one-kidneyed rabbit where the function had been compensated, the excretion of water administered per os and isotonic solution of sodium chloride injected intravenously was delayed, and that when a large amount of NaCl was given per os immediately after nephrectomy or compensation was established, it was likewise excreted. The excretion of water, however, was greatly hindered immediately after operation. MARINACI found a diminution of the renal function from the first till the second or at most the third day after unilateral extirpation of the kidney in the normal rabbit. From the first week on, he observed an increase in the amount of urine and in its urinary components. This accelerated function continued for a certain period, thereafter fluctuating for a time, then returned almost to the normal preoperative state, though

there was still a slight tendency of increase in function during one month after operation.

AKAIWA observed that there was no remarkable difference between the patients who had one intact kidney and the men whose kidneys were intact, as to the depression of the freezing point of the blood and excretion of indigocarmin and phloridin. He ascribed the increase in amount of urine and the decrease of its specific gravity to the changes in the absorption of water by the uriniferous tubules of the remaining kidney.

SUGIMURA ('15) also made it known that there was no noticeable difference in the patients with extirpated unilateral kidneys, when compared with normal cases by a fuuctional examination with phenolsulphonphtalein 1½-6 months after operation. Afterward ('23), the same author examined the function of the remaining sister kidneys in 15 patients and observed that the excretion of urea, uric acid, sodium chloride, creatinine and phosphoric acid of urine was very variable, and in many cases the excretion of phenolsulphonphtalein was not only delayed, but also discontinued.

KAWAI examined the function of the remaining kidneys in the rabbit with the method of ADDI, BURNET and SHERKY, and concluded that on the second or third day after unilateral extirpation the compensation in function of the sister kidney was not yet complete. On the fourth day, however, in the majority of the cases, the function of the sister organ was almost twice the normal, and on the fifth day or after, the compensation was already perfect in almost all cases.

Thus, after experimental removal of one side kidney from normal rabbits or the patients suffering from some disease, or even when one kidney was inadequately performing its function, the remaining kidney seems to show compensation sooner or later to a certain degree, considering the observations of various authors mentioned already. Moreover, the functional compensation or compensatory hypertrophy seems to be accomplished sooner and more perfectly in the animals, such as the rabbit, than in man.

In the present experiment in which the left ureters were firmly ligated, the urine reduced in amount markedly on the very day of the operation, as was the case in extirpated kidneys (FRISH and ZUCKERKANDL, etc.), and at the same time was more acidic in reaction

than before the operation, and also became denser, as already stated in chapter III., with an increase in its specific gravity and its total nitrogen. However, on the second or third day, the amount of urine increased gradually, but did not yet reach its preoperative amount, as some authors described. Despite this increase in the amount of urine, the total nitrogen content and the specific gravity continued to increase, and only about two weeks after operation the diurnal amount of urine as well as its character recovered its preoperative state.

7. Correlation among the Pelvic Fluid, the Normal and Post Operative Urine.

The normal urine was mostly alkaline in reaction, turbid and yellowish, and the post operative urine was also alkaline, though it showed some fluctuations. The pelvic fluid was of urinous character in the early period, turbid and dark brownish, or flesh juice-like, and in the course of time it became mostly clear and viscous. It then lost its original urinous nature at about the middle of the second stadium, and afterwards, especially from the beginning of the third stadium on, contained more protein.

In the early period of the first stadium the red blood corpuscles were observed in the pelvic fluid in a relative abundance, but in the course of time and before the end of the second stadium they reduced strikingly in number, especially in the fresh blood corpuscles. Up to this time various cylinders were also observed. In one case (No. 20, 200 days' experiment) crystals of triple phosphate, and in another case (No. 29, 173 days' experiment) crystals of calcium oxalate were seen.

pH. In the earlier periods the H-ion concentration of the urine increased, showing a weak acid reaction, but its degree was not so remarkable as that in the pelvic fluid. From about the middle of the second stadium on the H-ion concentration of the urine decreased in general, that is, indicating neutral and then alkaline reaction.

It is interesting to note that the reaction of the pelvic fluid changed in accordance with that of the urine, but the degree of the change was far more striking in the fluid.

The total average values of pH for the entire period of experiment were 7.15 in the urine, showing weak alkalinity, and 6.54 in the pelvic fluid, showing acid reaction respectively, as already described in the

preceding chapter.

Specific gravity. The average value of the specific gravity of the urine for the entire course of experiment is 1.015 and that of the pelvic fluid is 1.024, the former being less than the latter by 0.009. The specific gravity of the pelvic fluid in the obstructed kidney was greater than that of the urine of the same animal until the end of the first stadium, though it was rather less than that of the urine on the 27th day after operation and when the amount of the pelvic fluid reached the maximum. Afterwards it increased again and on the 120–148th day or at about the middle of the third stadium, when the fluid content in the pelvis showed a decrease, the specific gravity on the contrary increased. Thereafter the specific gravity of the pelvic fluid was always greater than that of the urine.

The interesting fact in this case was that the changes in the pH value were exactly in reverse to that of the specific gravity, and the fluctuation in the pelvic fluid was more remarkable than in the urine. In short, when the value of the pH was great, indicating alkaline reaction, the specific gravity was small, on the contrary.

Total nitrogen. The total nitrogen content of the pelvic fluid is large in the earlier period, showing 1–2 g. % till the 12th day, and is almost equal to that of the urine at the time of the dissection of the animals, though it is small in the later period or on the average throughout the experiment. From the 13th till 40th day it decreases gradually, showing about 1 g. %, and this is then followed by some fluctuations. The total N content in the pelvic fluid amounts about 88% of the urine after ureteral obstruction, on the average.

In the earlier period when the total N content in the pelvic fluid shows a somewhat large value, the weight of the renal parenchym shows also a remarkable increase, though the amount of the pelvic fluid does not yet amount to so much.

Protein. Protein is not proved in the urine of the normal and operated animals of the present study, while in the pelvic fluid it was almost proved, though its amount showed some fluctuations, and this difference just stated may be regarded as the chief sign by which these two fluids can be distinguished. Looking over the results of the whole course of the experiment, it was seen that on the 4th and 5th days protein reaction in the pelvic fluid was very faint; afterwards

TABLE XII.

Comparision of the pelvic fluid, urine and renal parenchym.

		Urine			Renal parenchym							
		normal or before operation (A)	after operation (B)	Pelvic fluid (C)	normal (D)	obstructed (E)	C—A	C—B	$\frac{A}{D} \times 100$	$\frac{B}{D} \times 100$	$\frac{C}{D} \times 100$	$\frac{E}{D} \times 100$
pH		7.15	7.15	6.54			-0.61	-0.61				
spec. gravity		1.015	1.015	1.024			0.009	0.009				
depr., freez. p.		1.02	1.07	0.76			-0.26	-0.31				
							$\frac{C-A}{A} \times 100$	$\frac{C-B}{B} \times 100$				
Total N		903	1037	968	2390	2500	6.2	-10.9	31.2	37.6	33.5	86.5
Urea N		767	858	202								
Protein N		—	—	339								
Ammonia N		27	32	76								
Creatinine N		30		22								
NaCl	mg. %	—	—	266	277	270					98.5	100.0
Water cont.		97.47	97.88	92.93	77.43	78.74	-4.7	-5.1	125.9	126.4	120.0	101.7
Dry subs.		2.53	2.11	7.09	22.56	21.26	180.3	236.0	11.2	9.4	31.4	94.3
Org. subst.		1.77	1.53	6.31	21.07	19.83	256.5	312.4	8.4	7.3	29.9	94.1
Inorg. subst.		0.72	0.58	0.79	1.51	1.35	9.7	36.2	47.6	38.4	52.3	89.4

it increased gradually and reached the maximum on the 120–173rd day or at the beginning of the third stadium, then showed some reduction. The reduction in the latter stadium corresponds to the period in which destruction of the parenchym as well as reduction in volume and weight of the obstructed kidney was considerably advanced.

As previously described under the heading of total nitrogen, the total N. content in the pelvic fluid seems to be derived almost entirely from the protein, excepting in the very earlier period, in which protein was not yet proved so much. Changes in the content of protein were almost parallel to that of total nitrogen. When the total N. in the renal parenchym and fluids was regarded derived wholly from protein alone and calculated as such, the amount of protein in the normal kidney, obstructed one, urine after operation and pelvic fluid was 18.1%, 15.6%, 6.8%, and 6.1% or 100, 86.5, 37.6 and 33.4 in ratio respectively. The protein content in the obstructed kidney was reduced by 14% under that in the normal kidney. In the pelvic fluid the protein content amounted to only 33% of the normal kidney, but it is less by 12% than in the urine. But we found actually only 2 g.% of protein or about 1/3 of the protein calculated from the total N. content of the pelvic fluid, so that the total N. content of the pelvic fluid could not be considered derived from some other substances such as urea and ammonia besides protein, while in urine the total N. is derived chiefly from urea. Moreover, it was noticed that when the specific gravity was great, and the pH was small, indicating weak acidity, the content of protein in the pelvic fluid was generally great, contrary to that of the urea.

Urea. In the early period till about the 10th day after operation the urea N. content of the pelvic fluid was almost equal to that of the urine, owing probably to the preponderance of the urine in the pelvic fluid, followed by a gradual decrease. When the disintegrative process in the parenchym was more advanced and the replacement of the glandular elements by fibrous tissue was striking, the urea content of the pelvic fluid seemed to be reduced as was mentioned by HERMANN. Moreover, the urea content of the fluid seems to have a relation with pH and specific gravity in such a manner that when the pH value was small and the specific gravity was great, the urea content was small. The average value of the urea N. content in the pelvic

fluid was 202 mg.% and that of the urine 858 mg.% amounting to about four times the former. As already mentioned, the total N. content in the pelvic fluid seems to be derived chiefly from the urea nitrogen in the earlier period, while it is derived chiefly from protein N. in the later period of the experiment.

Ammonia. The ammonia content of the urine was almost constant, showing 32 mg.% of N., while that of the pelvic fluid gave 76 mg.% of N. on the average, showing somewhat strong fluctuation, and amounting to 2.5 times that of the urine. On the 27th, 124th and 164-200th days, the ammonia N. content showed a considerable increase. On the 27th day the weight of the parenchym of the obstructed kidney reached the maximum, on the 124th day the organic substance, specific gravity and protein content of the pelvic fluid showed their maximum, and in the period which extended from the 164th till the 200th day the glandular elements of the obstructed kidney were replaced largely by connective tissue.

Creatinine. The creatinine N content was 30 mg.% in the urine, but 22 mg.% in the pelvic fluid, showing a decrease of 28% when compared with the former.

In my experiment, creatinine was proved in general in the first half of the experimental period, but contrary to the description of HERMANN, it was not proved in the latter half of the experiment, though in some cases a slight trace could be found.

Chlorine. Sodium chloride can be considered wanting in the urine, but in the pelvic fluid it was always found, showing 266 mg.% on the average. When it was compared with the content of the parenchym of the same organ, which enclosed the fluid, they were almost similar, that is, the content of sodium chloride in the parenchym was 270 mg.%, while in the hypertrophied sister organ it amounted to 240 mg.%, on the average.

Water content. The water content of the normal renal parenchym, the obstructed renal parenchym, the pelvic fluid, the normal urine and the postoperative urine was 77.43%, 78.74%, 92.93%, 97.47%, and 97.88% respectively, on the average. The ratio among the water contents of these substances was as follows:

$$\frac{\text{norm. ren. paren.}}{100.0} = \frac{\text{obstr. ren. paren.}}{101.7} = \frac{\text{pelv. fluid}}{120.0}$$
$$= \frac{\text{norm. urine}}{125.9} = \frac{\text{postoper. urine}}{126.4}$$

As is obviously seen from the above description, the water contents of the obstructed renal parenchym, the pelvic fluid, the normal urine and the postoperative urine are larger than that of the normal renal parenchym by 2%, 20%, and 26% respectively. Moreover, the water content of the pelvic fluid is less than that of the urine by 6%, so that the former lies somewhat nearer to that of the obstructed kidney, which enclosed the pelvic fluid, than to the normal kidney.

Dry substance. On the average, the dry substance is 22.6% in the normal kidney, 21.3% in the obstructed kidney, 7.1% in the pelvic fluid, 2.5% in the normal urine, and 2.1% in the postoperative urine, showing the following ratio:

$$\frac{\text{norm. kidn.}}{100.0} = \frac{\text{obstr. kidn.}}{94.3} = \frac{\text{pelv. fluid}}{31.4} = \frac{\text{norm. urine}}{11.2}$$
$$= \frac{\text{postoper. urine}}{9.4}$$

The content of dry substance in the pelvic fluid amounts only to 30% of that of the normal kidney and 33% or 1/3 of that of the obstructed kidney, while it corresponds to about 3 times that of the urine. This increase of the dry substance in the pelvic fluid is mostly caused by the increase in the organic substance, as will be seen from the relation given below in connection with the content of the organic substance.

Organic substance. The amount of organic substance in the renal parenchym and fluids gives the following relation:

$$\frac{\text{norm. kind.}}{100.0} = \frac{\text{obstr. kidn.}}{94.1} = \frac{\text{pelv. fluid}}{29.9} = \frac{\text{norm. urine}}{8.4}$$
$$= \frac{\text{postoper. urine}}{7.3}$$

The content of organic substance in the pelvic fluid amounts only to 30% of that of the normal and 32% of that of the obstructed kidney, while it corresponds to 4 times that of the urine after operation.

Expressed as percentage of dry substance, the contents of organ c

substance in the normal kidney, the obstructed kidney, the pelvic fluid, normal and postoperative urine are 93.4%, 93.3%, 89.0%, 69.9% and 72.5% respectively.

As is obvious from Table XII, the content of organic substance in the pelvic fluid in fresh material is greater than that in the normal urine by 2.4 times, while the content of dry substance in the pelvic fluid is greater than that in the urine by 3 times. Therefore, the increase in dry substance in the pelvic fluid must be caused by the increase in organic substance, while the changes in content of inorganic substance remain rather insignificant.

Inorganic substance. Similarly as in the preceding pages, the contents of the inorganic substance are now shown in ratio, the content in the normal kidney being taken as 100.

$$\frac{\text{norm. kidn.}}{100.0} = \frac{\text{obstr. kidn.}}{89.4} = \frac{\text{pelv. fluid}}{52.3} = \frac{\text{norm. urine}}{47.6}$$
$$= \frac{\text{postoper. urine}}{38.4}$$

The content of the inorganic substance in the obstructed kidney, the pelvic fluid, the normal and post operative urine amounts to 89%, 52%, 48%, and 38% of that of the normal kidney respectively. The difference in the content of inorganic substance among those tissues and fluids is not so remarkable as that in the content of organic substance. The content of inorganic substance of the pelvic fluid in fresh material is greater than that of the urine by 36%, and lies nearer by so much to that of the kidney.

The water content in the pelvic fluid is greater by 20% than that of the normal kidney, but it is less by about 5% than in the urine, that is, in the water content the pelvic fluid lies between the renal parenchym and urine, as already stated. The content of organic substance of the pelvic fluid amounts to only about 1/3 of that of the normal kidney, but it corresponds to thrice that of the urine. Moreover, the pelvic fluid contains some chemical compositions such as protein and chlorine, which are wanting in the normal urine. Therefore, the property of the pelvic fluid shows much closer resemb-rance to the composition of the renal parenchym, especially to that of the obstructed kidney, which enclosed the pelvic fluid itself, than that of the urine does.

As protein is not yet proved so much in the pelvic fluid in the earlier period, and the fluid is urinous, the total nitrogen in the pelvic fluid at this stage seems to have originated chiefly from the nitrogen of urine such as urea nitrogen. In the next period, or from the middle of the second stadium till the middle of the third stadium (70–173rd day), when the total N. content and protein content show an increase, the atrophic process in the parenchym is much advanced on the one hand, and the amount of the pelvic fluid much increased on the other hand, losing its urinous character and gaining protein and chlorine instead. Moreover, the total N. and protein nitrogen as well in the fluid increase parallel to atrophy to some extent.

Therefore, in this period the total N. content in the pelvic fluid would be mostly represnted by the protein nitrogen such as disintegration products.

On the average, the total N. content was 0.903% in the normal urine, 1.087% in the postoperative urine, 0.968% in the pelvic fluid, 2.890% in the normal renal parenchym and 2.500% in the obstructed renal perenchym, showing the following ratio:

$$\frac{\text{norm. kidn.}}{100.9} = \frac{\text{obstr. kidn.}}{86.5} = \frac{\text{postoper. urine}}{37.6} = \frac{\text{pelv. fluid}}{33.5}$$
$$= \frac{\text{norm. urine}}{31.2}$$

As is seen from the above ratio and Table XII, the total N. content in the obstructed kidney was reduced by 14% below the normal kidney. The total N. content of the pelvic fluid amounted to 34% of that of the normal kidney and 39% of that of the obstructed kidney. That is, as to the content of total nitrogen, the pelvic fluid was somewhat closer to the parenchym of the obstructed kidney which enclose the pelvic fluid itself, than to that of the normal kidney.

8. Correlation among the Pelvic Fluid, Renal Parenchym, and Some Body Fluids.

The Chemical Composition of the Pelvic Fluid Compared with that of the Various Other Body Fluids.

Up to the present time in the literature which I have seen, there have been hardly any detailed reports on the biochemical study,

especially quantitatively, of the fluid accumulated in the renal pelvis in cases of hydronephrosis caused by the interruption of the urinary passage or experimental obstruction of the ureter.

KAUFMANN ('11) reported that the fluid stagnated in the pelvis at an early period contained protein together with such urinary components as urea and uric acid, but at a later advanced period its urinous nature was lost by reabsorption through lymph vessels, and the fluid contained chiefly protein. This fluid is sometimes thick and colloidal, and its colour is sometimes blood-like or chocolate, and sometimes it contains cholesterine.

It is, however, regarded by him as originated partly from transudate of the capillary of glomeruli, partly from secretion or exsudate from the mucous membrane of the pelvis renalis. ASCHOFF ('13) pointed out that there was a great difference between the character of the pelvic fluid and that of the normal urinary composition, depending upon the admixture of inflammation with the process of filtration, secretion, and absorption. F. SUTER saw that the fluid of the hydronephrotic kidney was thinner than that of the sound opposite organ, and even at a hydronephrosis of high degree it was rather serous and of smaller specific gravity than the normal, notwithstanding the fact that it preserved well its urinous character and contained almost no protein, but seldom gas, sodium succinate, or paralbumin. M. HERMANN concluded that when the secretion accumulated in the pelvis, its water was absorbed first into the blood through parenchymatous tissue, decreasing the sodium chloride, sulphuric acid, phosphoric acid, and lastly the urea in the fluid, though creatinine still remained in abundance.

According to some authors the pelvic fluid had a specific gravity of 1010–15 and as a rule contained a small amount of protein than, though sometimes equal to, that of the blood, while the content of urea showed remarkable fluctuations.

E. ZIEGLER ('02) said that when the glandular parenchym was destroyed and the secretion ceased, the fluid in the pelvis increased partly with the secretion from the mucous membrane of the renal pelvis. The fluid was, therefore, usually clear, but sometimes brownish owing to admixture with blood and detritus, and sometimes contained cholesterin.

PONFICK ('10) says that the pelvic fluid originated from the capillary loop of the glomeruli, but no explanation was given whether it resulted from exsudation due to the inflammatory process in the glomeruli, or from transudation due to stasis. He regarded the content of BOWMAN's capsule as serum albumin, and concluded that albuminuria as well as cylinderuria might result also from "porogene Ursache". From the observations that, in the later period of his experiment, there was no parallelism between the degree of atrophy of the glandular parenchym and the degree of filling of the pelvis renalis, and that in the more advanced period, in which the glandular elements were almost disintegrated, the filling of the pelvis was still retained considerably, he concluded that the phenomenon was due probably to the leakage of fluid from the blood vessels in the renal pelvis. POSNER ('80), STRAUSS and GÉRMONT ('82), KUMITA ('09), etc. affirmed also that the fluid in BOWMAN's capsule was an albuminous exsudate. H. RIBBERT ('15) reports that the pelvic fluid was first urinous, but lost its salt gradually by diffusion, containing in abundance of protein which originated from the glomeruli. HERXHEIMER ('22) states that with the advance in atrophy of the parenchym, the pelvic fluid gradually became serous in nature, seldom becoming colloidal or showing so-called fatty detritus.

The statements given above obviously vary according to the authors, but we can state in brief that the fluid in the early period still had an urinous nature, but that afterwards it loses gradually its original urinous character and gains protein and other components instead.

As to the mechanism of the production of the pelvic fluid, some ascribed it to leakage of plasmatic fluid from the blood vessels, and others maintain that it depends upon diffusion. As to how the pelvic fluid, accumulated after obstruction of the ureter, is related with other body fluids of normal or pathological orgin in regard to the water content and other components, the data were gathered from various sources and are given in Table XIII.

The water content of the pelvic fluid is almost the same as that of the lymph of the ductus thoracicus in man, as is obvious from Table XIII and Fig. 13. The cases in which the water content is greater than in the pelvic fluid are listed in the ascending order of its magnitude: lymph from duct. thoracicus, chyle, pericardial fluid,

TABLE XIII.

Correlation among the pelvic fluid, renal parenchym and some body fluids.

	Water content %	Dry sub. %	** Org. sub. %	** Inorg. sub. %	** Total N %	** Protein %	** NaCl %	Spec. grav.	pH	Depr. of freez. point	Observer
Blood-corpusc. (rabbit)	63.35	36.65	..	..	..	..	..	..	..	..	WINTERSTEIN
Blood-corpusc. (man)	68.18	31.82	97.71	2.29	..	..	0.77	..	..	..	SCHMIDT
*Normal kidney (rabbit)	77.43	22.57	93.44	6.56	12.9	(80.30)	1.19	..	..	..	Author
*Right sister kidney	77.48	22.52	93.33	6.67	11.9	(74.10)	1.07	..	..	..	Author
*Left obstructed kidney	78.74	21.26	93.26	6.74	11.8	(73.50)	1.20	..	..	..	Author
Human blood	78.87	21.13	96.26	3.69	..	32.98	1.24	1.055	7.53	0.53	C. SCHMIDT
Blood of normal rabbit	81.69	18.31	..	..	..	16.57	1.58	– 60	7.33	0.57	WINTERSTEIN
Human-serum	90.15	9.85	91.61	8.63	..	..	3.58	..	..	..	WINTERSTEIN
Pus	91.37	8.63	..	..	..	39.30	..	31–40	..	..	HOPPE-SEYLER
Serum of rabbit	92.56	7.44	..	..	..	72.04	5.21	..	..	..	
*Pelvic fluid	92.93	7.09	89.00	11.00	13.65	(47.81)	3.75	1.024	6.54	0.76	Author
Inflamed lymph	93.27	6.73	..	..	..	..	..	..	..	..	LASSER
Hydrocel fluid	93.89	5.09	..	..	..	..	..	..	..	..	HAMMARSTEN
Lymph of duct. thorac.	95.00	5.00	..	..	..	78.20	..	..	..	..	LASSER (horse)
Chyle	95.86	4.14	81.88	18.11	..	68.12	14.01	..	..	..	SCHMIDT (horse)
Pericardial fluid	96.08	3.91	..	..	..	75.14	18.67	..	..	(man)	LASSER
Transudate in pleur. cav.	96.39	3.61	79.22	20.76	..	77.15	..	..	..		SCHMIDT
Stagnant lymph (horse)	96.76	3.24	..	..	..	..	..	..	..		LASSER
*Urine before operat.	97.47	2.53	69.96	30.04	35.69	..	..	1.015	7.15	1.02	Author
*Urine after operat.	97.88	2.11	72.97	27.03	51.66	..	..	1.015	7.15	1.07	Author
Peritonial transudate	97.89	2.11	53.55	46.44	..	52.61	..	..	..	..	SCHMIDT
Cerebro spinal fluid	98.35	1.65	51.52	48.48	..	48.48	..	..	..	..	SCHMIDT
Spermatcel fluid	98.68	1.22	24.50	..	..	24.50	..	..	..		HAMMARSTEN
Oedema-fluid	98.87	1.13	68.14	31.85	..	31.85	..	..	..		SCHMIDT

**Calculated from dry substance as 100 per cent. *Author's observation. Protein ( ): protein calculated from the total N.

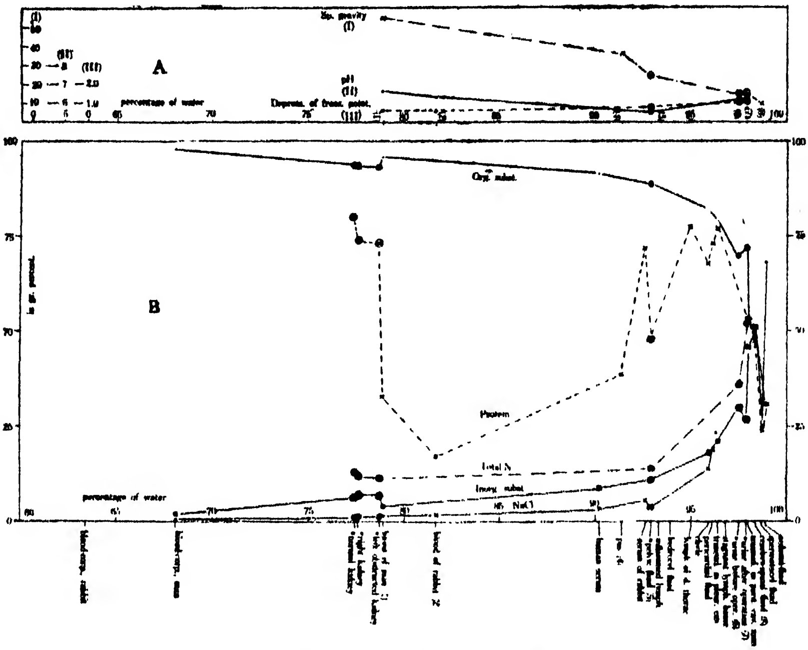

Fig. 13. Showing the relation among biochemical components of the stagnant pelvic fluid and body fluids. (Constructed from Table XIII)

pleural fluid of man, post operative urine of the rabbit, peritoneal fluid, cerebrospinal fluid, spermatocele fluid, oedema fluid, etc. The cases in which the water content is less than in the pelvic fluid are also listed in the descending order of its magnitude: hydrocel fluid, inflammation lymph, blood serum of rabbit, pus, blood serum of man, blood corpuscle of man, parenchym of obstructed kidney, blood of man, parenchym of sister kidney of the obstructed, and blood corpuscle of rabbit.

The difference in water content of the substances, however, may not necessarily indicate a difference in contents of the essential components, for we can imagine such cases in which the substances were merely diluted to adapt themselves to the physical condition of their environment, even though they maintain the original percentage distribution of the components. Therefore, in order to eliminate the influence of water, the relative amounts of various components were represented in per cent of the total dry substance content, and com-

pared. The results are shown in Table XIII and Fig. 13.

In Fig. 13, B., along the base line substances are arranged in the order of the magnitude of their water content, and the relative amount of their components in percentage of the total dry substance content are plotted against the vertical line.

Organic substance. The amount of the organic substance contained in the pelvic fluid is quite near to that of some physiological body fluid, such as blood serum, lymph from duct. thoracicus, chyle, and pericardial fluid, as well as some of the pathological body fluids such as inflammation lymph, hydrocel fluid, and transudate of pleural cavity, but it is far different from that of oedema fluid, spermatocele fluid and cerebro-spinal fluid. We also note that so far as the content of organic substance is concerned, the pelvic fluid resembles the renal parenchym, which enclosed the pelvic fluid itself.

The protein content in the fluids shown in Table XIII is highly variable, when compared with that of the content of the organic substance, especially owing to disproportionately small protein contents in the pelvic fluid, blood and serum (Table XIII and Fig. 13.). If these three cases are omitted, the protein content in the other fluids becomes parallel practically with the content of organic substance, the former representing a greater fraction of the latter. In the relative amount of protein content the pelvic fluid somewhat resembles transudate in the peritonial cavity and cerebro-spinal fluid. While, in the relation of protein content to organic substance content the pelvic fluid is closer to blood and serum, that is, protein content of the pelvic fluid represents a smaller fraction of the organic substance, as those of blood and serum, deviating from many other body fluids.

Moreover, the organic substance of the pelvic fluid may be regarded as consisting of some other organic substances such as amino acid besides protein, as is the case in blood and serum.

Inorganic substance. The content of the inorganic substance generally increases gradually in accordance with the increase of water content, until the water content reaches 95 per cent, after which, however, it is followed by a sudden increase. As to the content of the inorganic substance of the pelvic fluid, it lies rather nearer to blood-serum, chyle, and pericardial fluid, but is much less than the amount of the pericardial transudate, cerebro-spinal fluid, spermatocele

fluid, and the normal, as well as the post operative, urine.

Total nitrogen and NaCl. The relative amounts of the total N. as well as NaCl in these body fluids show the same relation as has been mentioned in regard to the inorganic substance, that is, they also show a sudden rise after the water content reaches 95 per cent. With respect to the total N. and NaCl contents in the pelvic fluid, they lie rather closer to those of the renal parenchym, which enclosed the fluid, as was the case with the protein content, but the total N. content is much less than that of the urine. The NaCl content of the pelvic fluid lies rather nearer to those of the blood-serum and renal parenchym, but is much less than those of the chyle and pericardial fluid.

H-ion Concentration the Pelvic Fluid (Table VIII and Fig. 8).

H-ion concentration in the pelvic fluid changes in almost concord with that in the urine for the entire course of the experiment, but in the former the change of H-ion concentration is more remarkable than in the latter.

The H-ion concentration shows abnormaly higher value in two periods, namely in the first stadium or the beginning of the experiment, and in the beginning of the third stadium or on the 120–140th day, in the pelvic fluid.

As to the cause of the higher concentration of H-ion in the first stadium, the following factors may be pointed out. After the ligature of the ureter the stagnant pelvic fluid increases in amount with elapse of time, and penetrates into the parenchym and fills its lymph space and interstitial meshes, thus producing an oedematous condition. The oedematous condition leads to the increase in its weight and volume on the one hand and to the disturbance of the vascular system on the other hand, resulting in stasis as well as accumulation of CO_2, which gives an acidity to the tissue, or leads to increase in H-ion concentration. According to OPPENHEIM a kidney produces lactic acid shortly after extirpation and the lactic acid attacks first the medulla and then the cortex, and as soon as the organ is disintegrated, it begins to show an alkaline reaction. If this view of OPPENHEIM may be granted in the obstructed kidney, the acidic substance such as lactic acid produced, would not be entirely neutralised by the alkalinity

of the blood, especially after strong disturbance of the blood circulation, thus showing an acidity in the early period.

With regard to the decrease of the H-ion concentration in the following period, we may reason that as soon as the parenchym, which at first falls into atrophy from a sudden disturbance, has adapted itself to some extent to its abnormal conditions, at the same time the proliferated or regenerated blood capillaries would absorb and carry away the acidic end products, thus giving an alkalinity to the pelvic fluid.

Second elevation on H-ion concentration at 120–140th day.

The H-ion concentration in an affected tissue is not always parallel with that of the blood. The former in general can increase independently of the latter in accordance with the degree of its affection or inflammation; for instance, pH is equal to 6.8 in chronic "kalter Abscess", while in pus from acute phlegmon it is equal to 6.0, while the reaction of the blood remaines almost constant during this whole process.

The pH of fluids in some pathological conditions is shown as follows:

(cited from KATO's Text book)

	(diagnosis)	(pH) (38°)
Pus from acute inflammation	acute furuncel	5.96
	phlegmon	6.05
	panaritium	6.06
	acute empyema	6.24
Pus from chronic inflammation	tuberculous coxitis	6.81
	abscess (chronica)	6.91
Serous transudate	pleural transudate	7.00
	tuberculous aciditis	7.03
Transudate	aciditis	7.21
	oedema fluid in subcut.	7.20

pH of skeletal muscle of frog (15°) { 7.25 (resting); 5.40 (fatigued); 6.13 (rigor) } MYERHOF & LOHMANN ('26)

As to the reaction of the renal parenchym, LIEBERMANN affirmed that it was acidic, while OPPENHEIM stated that it was alkaline in the rabbit, dog, cat and sheep, irrespective of the reaction of the urine, whether it is alkaline or acidic. According to the recent

observations of other investigators the H-ion concentration of the tissue or tissue juice, which hitherto was believed to be equal to that of blood, has been discovered not to be alkaline as the blood, and actually in the tissue pH is about 6.8–6.9 and in the tissue-juice about 6.7–6.9 at 38.5°, that is, the reaction of the tissue and of the tissue-juice which immerses the tissue, is either neutral or weak acid.

I am unable to state whether the extirpated kidney produces lactic acid which first attacks the medulla and then the cortex or not, as OPPENHEIM observed, but at least in my cases, in which 120–140 days had elapsed after the ureteral obstruction, the atrophic process in both medulla and cortex, particularly in the medulla, was much advanced and the pelvic fluid showed a strong acidity thereby. In other words, the more pronounced the pathological process, the higher the H-ion concentration of the fluid which immerse the tissue.

pH is 7.33 at 38.5°C. in the blood of the normal rabbit and 7.35 in the blood of man. The H-ion concentration of the various body fluids e. g. liquor cerebro-spinalis, orbital chamber fluid, amniotic fluid, sweat, and tears, etc. is almost equal to that of the blood. According to the result of my experiment, pH of the urine after obstruction is 7.15 on the average, while pH of the pelvic fluid of the obstructed kidney is 6.54 on the average. Furthermore, this last pH value does not correspond to those of the normal tissue & lymph above quoted, showing an acidity. On consideration of pH value, the pelvic fluid neither belongs to urine, nor to the normal body fluids, that is, the pelvic fluid may be regarded as a specific fluid from the standpoint of pH.

Specific gravity and depression of the freezing point. The specific gravity of the pelvic fluid (1.024) is somewhat great than that of the urine after operation, and is also greater than those of the urine of the normal rabbit and man, and of most body fluids.

The depression of the freezing point of the pelvic fluid (0.76) is greater than that of human blood (0.53) and the blood of the rabbit (0.57), but it is remarkably smaller than that of the urine of the rabbit (1.07) after operation, or normal human urine (1.3–2.3).

In short, the pelvic fluid is rather a specific fluid which resembles neither physiological body fluids, such as cerebro-spinal fluid, nor pathological fluids, such as oedema fluid, and belongs neither to simple

transudate, simple exsudate nor to exceretions such as urine which is its predecessor. But the pelvic fluid resembles more closely some other body fluids, such as blood and serum, which have relatively smaller water content and larger organic substance content, and the parenchym such as the obstructed kidney, which enclosed the pelvic fluid itself. In other words, the pelvic fluid may be regarded as a specific fluid containing urinous constituents and disintegration products of the renal parenchym in various proportions and amounts.

V. GENERAL REMARKS AND CONCLUSION.

General Remarks.

It is evident from the preceding statement that a ligation of the ureter produces a profound alteration in the kidney concerned, morphologically as well as chemically. Among the alterations, we notice an increasing weight and volume of the kidney as a whole in association with accumulation of the pelvic fluid, showing a remarkable increment in its weight and volume over the normal and sister organs.

At the same time the kidney becomes globular in its form. These alterations just mentioned seem to be due to the permeation of the urinous pelvic fluid into the meshes of the parenchym, as might be interpreted from the oedematous appearance of the organ. This simple assumption seems further supported by the fact that all the uriniferous tubules show strong dilatation in their lumens, becoming reticular and yielding thereby the greatest amount in water content.

This increase in weight at an early period is followed by a gradual diminution at a later advanced period. Associated with this decrement, one observes a loss in almost all the gradular elements excepting a very few strongly altered glomeruli and collecting tubules. By such a degenerative process, the disintegrated products find their way to the pelvis and thus increase the amount of pelvic fluid, on the one hand, and deform the original shape of the kidney to a membranous sack of connective tissue, on the other.

Following such advanced disintegrating processes, equally profound changes occur to the chemical components of the tissue itself and to the pelvic fluid. Among the chemical changes which occured in the parenchym, we may enumerate an increase of water content and

decrease of dry, organic, inorganic and fatty substances and total nitrogen content, compared with those of the normal or the hypertrophied sister kidney.

The stagnant pelvic fluid, as was fully stated in preceding pages, increases gradually in its amount after the ureteral obstruction, but later decreases gradually, due probably to absorption by the surrounding parenchyma. In the earlier period, when the parenchym shows a most remarkable increase in its weight and in its water content, thus presenting an oedematous appearance, the pH value of the pelvic fluid is quite low or acid in reaction. having a higher value of the specific gravity. The depression of the freezing point is considerably smaller due probably to the presence of protein as a result of the degeneration of the kidney tissues.

In the earlier period, when the pelvic fluid is still urinous, its total nitrogen content is greatest and almost equal to that of the urine, which in turn shows a considerable decrease for a few days, but again is followed by an increase in association with the increase of protein content or with the progressive atrophy of the parenchym.

It is interesting to note that the pelvic fluid rather resembles the blood serum and renal parenchym than the urine and oedema fluid so far as the relative contents of organic and inorganic substances, total N and protein in dry substance are concerned. In the NaCl content, the pelvic fluid rather comes closer to blood serum than to the renal parenchym. In the specific gravity and the depression of the freezing point the pelvic fluid lies between blood and urine, and in the pH value it is smaller or more acid in reaction than those given by blood and urine.

In short, though the pelvic fluid is urinous in composition in the earlier period, it loses gradually its original urinous nature, especially by the addition of protein and chlorine to it. In other words, the pelvic fluid found in the advanced hydronephrosis no longer belongs either to simple transudate or to exsudate or to excrete, but may be considered as a special body fluid which contains urine components and disintegration products of the renal parenchym in various proportions.

What happens to the excretory function of the rabbits having such abnormal or obstructed kidneys is revealed from the condition of the

urine.

The quantity of the urine diminishes remarkably on the very day of the ureteral obstruction, and 24 hours after operation it shows a tendency to increase, but does not yet reach to the normal value. This condition continues for some days. The H-ion concentration, specific gravity and depression of the freezing point of the urine have a tendency to increase after operation. The nitrogen-containing substances of the urine, namely, urea, ammonia, creatinine, etc., increase remarkably, in general, in the earlier period of the experiment.

The water content of the urine diminishes also after operation, and the dry substance shows an increase, in which both organic and inorganic substances, especially the latter, increase.

In short, the urine is in a concentrated state, giving weak acidity, for some days after operation, but afterwards it approaches gradually to the normal state, despite the fact that non-protein nitrogen, urea and NaCl appear continually to accumulate in the blood after operation.

This remarkable ability of restoration of the excretory function under nearly total destruction of one side of the kidney is due to the compensated hyperfunction of the remaining sister kidney. Indeed, we have already noted that the sister kidney increases in weight and volume gradually in all directions to the end of the second stadium, or to about the 100th day after operation, though it shows a tendency toward gradual decrease afterwards, probably due to the gradual adjustment of the body as a whole to the unnatural condition and the consequent adaptation of the sister kidney itself to increased function with smaller volume.

The increase of the compensated kidney never attains double the weight or size of the normal control kidney, though functionally the former kidney performs nearly equivalent work to the two kidneys.

This is enabled by the highest degree of responsed enlargement of the glomeruli and convoluted portions, which perform the principal renal function.

On histological observation, I am inclined to believe that the enlargement of the sister kidney must result mostly from hypertrophy and partly from hyperplasia of the glomeruli, convoluted portions and interstitial connective tissue. Moreover, it is seen that the glomeruli increase in general in their diameter, but that they decrease number

in a certain area slightly. The so-called "filtration area" or the mean area of the glomeruli multiplied by the total number of the glomeruli in the area (VILLA-SANTTA), is somewhat greater than that of the normal. From this fact we can anticipate also that the hapertrophied sister organ carries on more fuction than the normal.

Conclusion.

The left kidney, obstructed by ligating the left ureters, was compared with its sister hypertrophied kidney as well as with the normal control kidney from the anatomical and biochemical standpoint, and the results are summarized and concluded as follows.

The weight and volume of the obstructed kidneys increase rather rapidly and reach the maximum values within 70 days after operation, and then decrease slowly and gradually. To be more precise, the parenchym attains its maximum weight much earlier than the dilatation of the renal pelvis or the accumulation of the pelvic fluid. In association with the changes in weight and volume, several characteristic changes take place with respect to histological features and chemical components. From these characteristic changes just alluded to the course of the alteration extending over a year may be divided into three stadiums.

I. Stadium: This stadium covers a period extending from the first to the 27th day after the ureteral obstruction and the following alterations are noted.

A. Anatomical.

1. The obstructed kidney increases its weight and volume somewhat rapidly. It assumes a round form with several hunched lobules and a ragged lateral margin. The surface of the semispherical portion adjoining the renal hilum is stretched, but is not yet transparent, as is seen in the next stadium, while in the other semispherical portion the parenchym is still considerably maintained.

2. Not only the total weight of the obstructed kidney but the weight of the parenchym is always heavier than that of the normal or hypertrophied sister kidney and also heavier than the stagnant pelvic fluid. That is, the percentage increase of the obstructed kidney is 200.5% and that of the parenchym 114.7% over the normal kidney. From the averaged values we find that the obstructed kidney shows

an increase of about 30% over the normal and of 20% over the sister organ in longitudinal axis, 50% over the normal and 34% over the sister organ in transversal axis, and 92% over the normal and 88% over the sister organ in dorso-ventral axis.

The estimated volume from these measurements gives the increase of 270% over the normal and 200% over the hypertrophied sister kidney. On the other hand, the sister kidney shows an increase of 8% in length, 12% in transversal and only a trace in dorso-ventral axis over the normal, giving thus the increase in the estimated volume of about 20%, though the increase in weight is as much as 55.6% over the normal.

3. The renal pelvis is dilated but very slightly, and the amount of the fluid accumulated in the pelvis is only 3.5 cc. on the average.

B. Histological.

1. The uriniferous tubules and BOWMAN's capsules are conspicuously dilated and the degree of dilatation is noted in the following order: The collecting tubules, distal convoluted portions and HENLE's loops.

2. Stasis of blood is very remarkable and capillary loops of the glomeruli are filled heavily with blood.

3. Cylinders in the uriniferous tubules increase considerably towards the end of this stadium and are found almost at the distal part of HENLE's loops.

C. Biochemical.

Renal parenchym.

1. As much as the spongy structure is best developed in the obstructed kidney at this stadium, we find thereby chemically that the water content, inorganic substance, total nitrogen and fatty substances are greatest, while the contents of dry and organic substances and NaCl are smallest of all three stadiums.

2. When, however, the obstructed kidney is compared with the normal or hypertrophied sister kidneys in this stadium, we find an increase in water content and a diminution of the contents of dry, organic and inorganic substances, total N and fatty substances.

3. Is it noted that as to the contents of water, dry, organic and inorganic substances, total N and fatty substances in the hypertrophied

sister kidney are closer to the normal than to the obstructed kidneys, though the NaCl content is least in the sister kidney.

Pelvic fluid and urine.

1. The values of the specific gravity and the contents of the total N, NH_3, creatinine, dry and organic substances of the pelvic fluid in this stadium are greatest, while the values of the pH and the depression of the freezing point and the contents of protein, NaCl, and water of the pelvic fluid are smallest of all three stadiums.

The urea content is higher than that of the third stadium but lower than that of the second stadium.

2. The values of the specific gravity and the contents of the organic and inorganic substances, and NH_3 in the pelvic fluid are greater, while the values of the pH, depression of freezing point, water content and urea in the pelvic fluid are smaller than those of the urine after operation in this stadium. The total N content of the pelvic fluid is almost equal to that of urine, but far smaller than that of the renal parenchym.

3. The water content of the pelvic fluid is greater than that of the renal parenchym, while the contents of the organic and inorganic substances, and NaCl of the pelvic fluid are smaller than those of the renal parenchym.

II. Stadium: This is the period extending from the 28th to the 105th day.

A. Anatomical.

1. The total weight and volume of the obstructed kidney continues to increase and reach the maximum at the middle (70th day) of this stadium, and then begin to decrease gradually, though they are still heavier and considerably larger than those of the normal or hypertrophied sister organs. The obstructed organ presents thereby a large spherical sacciform shape like a tumour with a translucent semispherical portion on the side of the renal hilum.

2. In this stadium, the total weight of the obstructed kidney shows an increase of 157% over the normal weight, while the weight of the parenchym of the obstructed organ without the pelvic fluid shows a slight increase of 2.5%, but it shows a decrease of 43.5% when compared with that of the first stadium.

3. We thus find in the obstructed kidney the increase of 32% in length over the normal, 13% over the sister kidney, in the transversal axis 45% over the normal and 17% over the sister kidney, and finally in the dorso-ventral axis 82% over the normal and 53% over the sister organ. The computed volume from the three measurements shows an increase of 250% over the normal and 98% over the sister organ.

4. Dilatation of both the renal pelvis and ureter becomes more remarkable, and the pelvic fluid gives its greatest value, amounting to 11.2 cc.

B. — Histological.

1. Progressive atrophy or disintegration of the glandular elements and gradual increase of proliferation of the interstitial connective tissue are characteristic features in this stadium. Concerning the atrophic process of the parenchym, atrophy of the medullary portion is in general prior to that of the cortical portion, showing a more advanced degree of atrophy. The parenchym in the papillar portion of the renal pyramid is especially dissipated by pressure, and the course of the uriniferous tubules there becomes disorderly and sometimes runs parallel to the surface of the organ.

2. In this period in which the atrophy is fairly well advanced, the cortical portion can be distinguished from the medullary portion by the position of the vasa arciformia. Of the elements of the kidney, the proximal convoluted portions are least resistant, while the glomeruli and collecting tubules are most resistant.

The glomeruli remain in a relatively good condition even after the disintegration of almost all other elements of the kidney, showing no hyalin degeneration. Some of the collecting tubules may be similarly long maintained.

3. With the atrophy of the proximal convoluted portions the proliferation of the interstitial connective tissue begins.

4. The distribution of blood is strongly disturbed and the parenchym becomes anaemic, but the capillary loops of the glomeruli still contain blood to a considerable amount.

5. Cylinders in the uriniferous tubules are not seen from about the middle of this stadium.

C. — Biochemical.

Renal parenchym.

1. In this stadium the spongy appearance of the obstructed kidney is rather sporadical and of more slight degree than in the preceding stadium. The contents of water and inorganic substance of the obstructed kidney in this stadium are greater than those of the first stadium but less than those of the third stadium, while those of the dry and organic substances and NaCl are less than those of the first stadium but greater than those of the third stadium.

2. In the obstructed kidney, as in the preceding stadium, the contents of water and NaCl are greatest, while the contents of dry, organic and inorganic substances, total N and fatty substances are smallest, when compared with those found in the normal and in the hypertrophied sister kidneys.

3. In the hypertrophied sister kidney we find that the contents of the dry and organic substances are greatest, while those of NaCl and the inorganic substance are smallest, when compared with those in the normal and obstructed kidneys, though the total N content is less than the normal but greater than the obstructed kidney.

Pelvic fluid and urine.

1. In this stadium the values of the pH and depression of freezing point, and the contents of the urea, NaCl and water in the pelvic fluid are greatest of all three stadiums. The specific gravity and the contents of the total N, NH_3, dry, organic and inorganic substances, in this stadium are smallest of all three stadiums.

2. The content of the organic substance of the pelvic fluid is larger than that of the urine, while the depression of the freezing point, and the contents of water, total N, urea, and NH_3 are smaller than those of the urine.

The specific gravity, pH and the content of the inorganic substance in the pelvic fluid are almost equal to those of the urine.

3. The water content and NaCl of the pelvic fluid are greater than those of the renal parenchym, while the contents of the organic substance and total nitrogen in the pelvic fluid are smaller than those of the renal parenchym.

III. Stadium: This is the period extending from the 105th day to the 375th day or to the end of the experiment.

A. — Anatomical.

1. From the middle of the second stadium on, the total weight and volume of the obstructed kidney decreases gradually in accordance with the days elapsed, presenting a small sacciform tumour-like shape with a strongly atrophied parenchym and being very translucent on the semi-spherical pole adjoining the renal hilum.

2. In this last stadium the conditions in the weight of the obstructed kidney are just reversed to those of the first stadium, namely the weight of the parenchym, excluding its pelvic fluid, is far smaller than that of the weights found in the preceding stadiums, giving a reduction of 51.8% from the second stadium and 164% from the first stadium, and also a reduction of 48.3%, when compared with that of the normal.

The total weight of the obstructed kidney at this stadium shows a decrease of 132% below that in the second stadium, and 175% below that in the first stadium, while is still shows an increase of 25.5% over the normal.

In this last stadium the value of the axis and the computed volume of the obstructed kidneys shows remarkable decrease, contrary to the preceding stadiums, as is the case in the weight of the kidneys, although some of them still show some increase over the normal. Thereby, the length of the longitudinal axis shows a decrease of 10% below the normal and sister organs, that of the transversal axis shows also a decrease of 8% below the sister organ, but that of the transversal and dorso-ventral axis of the obstructed kidney still shows some increase over the normal and sister organs. The computed value of the obstructed kidney still shows an increase of 58% over the normal, but a decrease of 10% below the sister organ.

3. Dilatation of the renal pelvis and ureter increase very strongly and the amount of the pelvic fluid measures 5.1%cc. on the average, showing a considerable decrease below that found in the preceding stadium.

B. — Histological.

1. Replacement by proliferated connective tissue of almost all the glandular elements of the obstructed kidney is a characteristic feature in this stadium. The more advanced the period, the more distinct becomes the proliferation of the interstitial connective tissue

and the proliferated connective tissue seems to fuse together with those from the walls of the blood vessels and capsula fibrosa. But in such an advanced stage of atrophy as this, some remainders of strongly altered glomeruli and collecting tubules of ring form can be seen.

2. The parenchym is, in general, very ânaemic, but blood may be still found in the blood vessels, and the capillary loops of the glomeruli still contain some blood in this stadium, excepting those in the very later period of this stadium.

C. — Biochemical.

Renal parenchym.

1, In this last stadium the spongy structure of the parenchym of the obstructed kidney is no longer observable and thereby its contents of water and inorganic substance are smallest, while the contents of dry and organic substances and NaCl are greatest of all three stadiums.

The contents of fatty substances and total N of the obstructed kidney are smaller than those of the first stadium, but larger than those of the second stadium.

2. In the obstructed kidney, the contents of water and NaCl are greatest, while the contents of dry, organic and inorganic substances and fatty substances are smallest in this stadium as in the preceding two stadiums, when compared with those found in the normal and hypertrophied sister kidneys. But the content of the total N of the obstructed kidney is smaller than that of the normal, but larger that of the sister kidney.

3. Similarly, we find that the contents of the dry and organic substances of the sister kidney are greatest, while those of water, total N and NaCl are smallest, when they are compared with those of the normal and obstructed kidneys.

But the contents of the inorganic substance and fatty substances are less than the normal but larger than those of the obstructed kidney.

Pelvic fluid and urine.

1. In this last stadium the contents of protein and inorganic substance of the pelvic fluid are greatest, while those of the urea and

creatinine are smallest of all three stadiums. The values of the pH, NaCl and water content are greater than those in the first stadium, but smaller than those in the second stadium. As to the values of the specific gravity, total N, NH_3, organic and dry substance contents, they are smaller than those in the first stadium, but greater than those in the second stadium.

2. The pH and the contents of the organic substance and NH_3 in the pelvic fluid are greater than those of the urine, while the specific gravity, the depression of the freezing point and the contents of water, inorganic substance, total nitrogen and urea in the pelvic fluid are smaller than those of the urine.

3. The water content of the pelvic fluid is greater than that of the renal parenchym, while the contents of organic and inorganic substances, total N and NaCl of the pelvic fluid are far smaller than those of the parenchym.

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EXPLANATION OF THE PLATES.

PLATE XVI.

The figures from 1 to 6 show the alteration in size and form of the kidneys during the experiment, especially in the left obstructed side, the ureter of which were ligated (showing about $\frac{3}{4}$ size).

a — left obstructed kidney. b — somewhat compensatorily enlarged sister kidney of the right side.

Their characteristics are given in the following table.

Number of figures	Experiment period (day)	Serial number of rabbit	a: Total weight (g.)	a: Size (mm.) L	a: Size (mm.) B	a: Size (mm.) Th	a: Stagnant pelvic fluid (cc)	a: Weight of parenchym (g.)	b: Weight (g.)	b: Size (mm.) L	b: Size (mm.) B	b: Size (mm.) Th
1	27	33	35.0	51	45	35	12.0	14.0	10.0	35	24	17
2	70	28	36.0	41	35	33	30.0	6.0	8.5	32	22	14
3	75	23	23.0	45	35	25	13.0	8.0	8.2	30	23	15
4	140	35	7.5	26	21	10	4.5	2.0	9.0	31	25	10
5	173	29	3.7	23	18	05	0.5	3.0	10.4	37	25	12
6	234	6	4.1	22	15	10	2.7	1.4	7.9	30	20	15
7	Longitudinal section (through the lateral crest to the hilum) of Fig. 2, a., showing strong cicatrization of the renal parenchym and strong proliferation in the renal column of BERTINI.											

(L)=Length of kidney. (B)=Breadth of kidney. (Th)=Thickness of kidney.

PLATE XVII.

Fig. 8. A preparation from the compensatorily hypertrophied right sister kidney (Serial No. 2, experiment period 375 days, ×15.).

Fig. 9. Showing, in the centre, a considerable dilatation in the pelvis of the left obstructed kidney at the beginning hydronephrotic alteration (No. 44, exper. period 4 days, ×10.).

Fig. 10. Showing a characteristic reticular feature of parenchym caused by the enlargement of lumens of the uriniferous tubules, in the first stadium of the hydronephrotic alteration (No. 4, exper. period 45 days, ×60.).

Fig. 11. Microscopical illustration of Fig. 7, showing still persisting renal elements (No. 28. Exper. period 70 days, ×50.).

PLATE XVIII.

Fig. 12. Showing a characteristic feature in the second stadium, in which progressive disintegration is conspecuous especially in the glandular elements, accompanying proliferation of the interstitial connective tissue (No. 3, exper. period 163 days, ×20.).

Figs. 13 and 14. Showing a characteristic feature in the third stadium, in which far more advanced degeneration is conspicuous in the glandular elements, accompanying much more active proliferation of the interstitial connective tissue (No. 2, exper. period 375 days, Fig. 13, ×72; Fig. 14. ×15.)

Fig. 1.

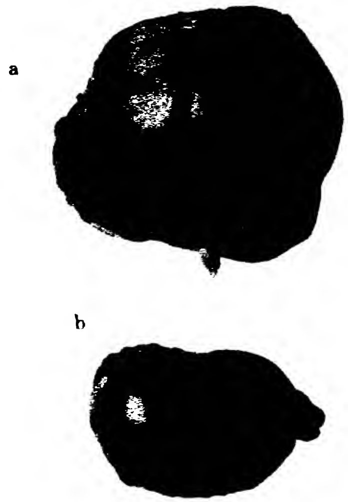

Fig. 2.

Fig. 3.

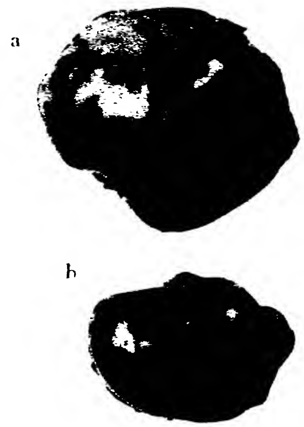

Fig. 4

Fig. 5.

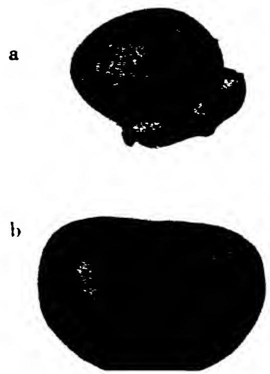

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

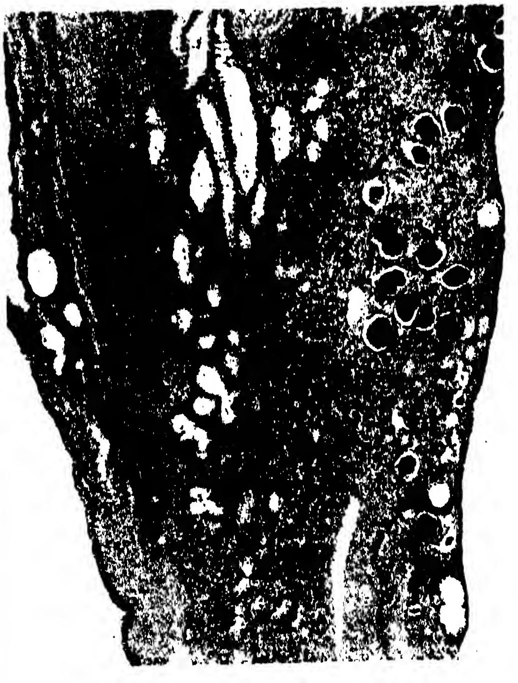

Fig. 11.

S. HASEYAMA: Histological and Biochemical Changes in Hydronephrosis.

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Fig. 12

Fig. 13.

Fig. 14.

S. HASEYAMA: Histological and Biochemical Changes in Hydronephrosis.

Report on the Calcarea obtained by the Hamburg South-West Australian Expedition of 1905.

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(With Plates XIX — XXI and 17 Text-figures)

(Received Sept. 10, 1931)

The Calcareous sponges collected by the Hamburg South-West Australian Expedition of 1905 were originally examined by Mr. Harold Row of the King's College of London University.

After his untimely death in February 1919 the second author of the present paper was asked to undertake the continuance of the work by the late Professor Dendy of the same college. It was in November 1921 and while he was staying in London that the material thus fell into his lot.

The collection contains a large number of specimens belonging to 43 named species, which have been assigned to 12 genera and 7 families. Of the species 16 are now described for the first time, and the remaining 27 are those previously known. No new genera are here described.

The complete list of species is as follows.

There have now been made a considerable number of collections of calcareous sponges from various parts of Australia, and amongst them there occur some of the most important collections ever obtained.

The following may be mentioned as of great interest at once.

From the Torres Straits, a few species obtained by the Challenger Expedition and reported on by POLÉJAEFF in 1883.

From the East Coast, a fairly large collection obtained and reported on by VON LENDENFELD in 1885.

From the vicinity of Melbourne, (1) a large number of species described by CARTER (1885–1886); (2) a still larger collection reported on by DENDY (1892), and used by him as a foundation for his revision of the classification of the group.

From New Zealand, about a dozen species were described formerly by KIRK, and recently 22 species were recorded by BRØNDSTED (1926).

From the western coast of Australia there have been known about ten species only, described by DENDY and FREDERICK (1924), and thus our knowledge of the Calcarea fauna of that locality is very meagre.

The present collection has, however, most thoroughly supplied that want, and we have now a really good knowledge of the calcareous sponge fauna of the whole of the southern half of the coast of Australia.

Family **Homocoelidae** DENDY

Genus LEUCOSOLENIA BOWERBANK

1. **Leucosolenia lucasi** DENDY

Leucosolenia lucasi, DENDY, 1891, p. 45, Pl. I, fig 1; Pl. IV, fig 1; Pl. IX, fig. 1; TOPSENT, 1907, p. 539; KIRK, 1893, p. 178, Pl. XXII, figs. 2a–f; DENDY and ROW, 1913, p. 723; BRØNDSTED, 1926, p. 298, fig. 1.
Leucosolenia bella, DENDY and ROW, 1913. p. 721.

This extremely pretty species is represented in the collection by five specimens (AJ_2, AJ_8, $AZ_1\alpha$, $Z_1\eta$, AW_2).

Specimen AW_2 is small and consists of about half a dozen of Ascon-tubes arising from a creeping stolon, which is somewhat branched, and from which all individual persons arise separately. Each of the persons is about 1 mm. high and 0.5 mm. in diameter and each ends in a widely open osculum.

Specimen AJ_8 is attached to sea-weed and forms a dense bushy mass of about 13 mm. diameter and about 8 mm. high. The colony belongs to DENDY's section Simplicia of the genus (DENDY, 1891), and consists of a mass of Ascon-tubes which frequently branch, but

never anastomose, save possibly very occasionally in the lowest parts of the colony. The individual tubes are of small size, though they vary to some extent, measuring from 1 to 4 mm. in length and 0.3 to 1 mm. in diameter. Each of the full-grown tubes possesses an osculum at its distal end of nearly the same width as the tube itself.

Specimen AJ_3 is larger than AJ_2 but is nearly the same in general appearance and in minor structure.

Each of the remaining two specimens ($AZ_1\alpha$, $Z_1\gamma$) forms a small bushy colony consisting merely of 8 or 10 Ascon-tubes.

As stated above, this species is very variable in form, either being composed of solitary Ascon-tubes arising from creeping stolon or forming dense bushy masses. The shape of the oxea projecting from the sponge-surface also varies greatly. They are sometimes long and slender and sometimes shorter, thicker and straight with rather bluntly pointed ends.

Previously known Distribution. — Outside Port Phillip Heads (DENDY); Cook Strait, N. Z. (KIRK); Pegasus Bay, Stewart Island, N. Z. (BRØNDSTED).

Localities and Register Nos. of Specimens. — Geraldton District (Station 31), AJ_2, AJ_3, $AZ_1\alpha$, $Z_1\gamma$; Albany District (Station 63), AW_2.

2. Leucosolenia clathrata (CARTER)

Leucetta clathrata CARTER, 1883, p. 33, Pl. I, figs. 13–17.
Clathrina tripodifera var. *gravida* CARTER, 1885–1886, p. 507.
Leucosolenia tripodifera var. *gravida*, DENDY, 1891, p. 68.
Leucosolenia intermedia KIRK, 1895, p. 208, Pl. IV, fig. 2.
Leucosolenia clathrata, DENDY and ROW, 1913, p. 724.

This extremely interesting species is comparatively common in the collection, and has been obtained from several localities, while the specimens vary in size from minute, almost Olynthus-like individuals, to masses 100 mm. long and 30 mm. wide.

The colour of a very small specimen is invariably perfectly white, but in older examples the sponge usually takes on a more or less deep tinge of yellow or even brown, due to its having, in the course of its growth, incorporated in itself a considerable quantity of the mud or sand that may be near it. The texture of the large specimens is always comparatively firm, much more so than is the case with most

Leucosolenias, and the deneness of the sponge enables it to retain its shape even under some pressure. The surface is always quite smooth.

The species is always found growing on some support, usually an alga or Polyzoan, firmly attached by a considerable surface in the older specimens, and by a slender stalk in very young ones.

This species was first described by CARTER (1883) as *Leucetta clathrata*, and in the description which he gave on the sponge he refers to its general appearance in the following words: —

" Small, flat, sessile, cake-like in form, more or less subcircular, slightly convex....consisting of a fibro-clathrous-spicular structure, which, spreading upwards from a continuous layer adherent to the frond of the foliaceous corraline on which it has grown, terminates above in a free surface that presents a solid vermiculo-reticulation in prominent relief."

In dealing with the spiculation, he lays considerable stress upon the very striking " tripod " spicules that form a dermal layer on the surface of the sponge.

Later, (1885–1886), he described *Clathrina tripodifera*, now the type of the genus *Dendya*, and, undoubtedly misled by the great similarity of the dermal spicules in the two species, decided to sink the earlier name, and to consider *Leucetta clathrata* merely as a variety of *Clathrina tripodifera*, i. e., var. *gravida*, in which position it has remained until now. However, between *Dendya tripodifera* and *Leucosolenia clathrata* there are a number of very important differences, the chief being the general shape of the sponge-colony and the type of canal system. The quotation from CARTER's original description shows that his specimens were individuals of the ordinary " Clathrinid " type, forming a low-lying reticulation of Ascon-tubes, and totally different to the erect " radiate " colony of *Dendya*, and that the two species have been so long confounded must undoubtedly be put down to the fact that *Leucosolenia clathrata* has never been recognized since CARTER first described it until now. The species is, however, represented by a considerable number of specimens of all sizes in the present collection, and we have been enable to make a complete re-investigation of its characters, and in particular of the canal system, which presents certain very curious resemblances to that of *Dendya*, not referred to

by CARTER. We think, however, that the description of the canal system given below will show that these resemblances are not evidences of close relationship, but merely due to convergence.

In the youngest specimens in the collection there is a central gastral cavity with a single osculum, while two or three small tubes ramify and anastomose on the wall, apparently opening into the gastral cavity at both ends. No specimen occurs actually in the Olynthus condition, but such specimens as the one above described are obviously but little removed from it, and specimens are present in the collection of all intermediate sizes between this and the largest.

In examples of about 5 mm. in diameter, when the sponge is usually in the form of a small, compact cushion, there is nearly always an irregular, but well marked central cavity, undoubtedly corresponding to the central gastral cavity of the smaller forms, and around this spreads a close network of branching and anastomosing Ascon-tubes, without any orientation whatsoever in the sponge. At this stage the specimen forms a very typical " Clathrina ", save for the central gastral cavity, and this condition characterizes almost all the specimens in the collection. In the largest specimens, however, the external part of the colony shows a remarkable tendency to take on a radial arrangement, so much so that the whole of the tubes here lie parallel, with the blind end pointing outwards. Internal to these radially arranged tubes there occurs the usual irregular network, but without any central cavity, which has apparently been entirely obliterated by the invasion of the tubes. The external surface of these specimens, therefore, is somewhat different in character to that of smaller individuals. In the latter the surface is composed of the lateral walls of the anastomosing tubes, while in the former case it is made up of the terminal portions of radially arranged tubes, more or less fused together by mesenchyme, in such a way as to form a surface-reticulum very similar in appearance to the surface of the others. A further distinction between the two cases is that the openings on the surface of the larger specimens are true intercanals, lying between and parallel to the surronunding tubes, while in the smaller specimens their relationship to the sponge tubes is entirely irregular and haphazard.

Further, there can be not doubt that these large specimens belong to the same species as the smaller individuals, as some of these latter

show distinct indications of this radial arrangement in the superficial parts of the colony, indications which show that these specimens are just initiating this new type of growth; indeed, in some cases there can be distinguished traces of this radial arrangement throughout the colony, though in most no signs of it can be seen save in the most superficial regions. As stated above, the earlier tubes undoubtedly do not develop as radial outgrowths.

It is hardly necessary, though perhaps advisable, to say that CARTER's statement that the tubes are solid is quite incorrect.

These peculiarities of the canal system have rendered it very difficult to assign the species satisfactorily to either *Leucosolenia* or *Dendya*. The central gastral cavity found in all but the largest spencimens, and the radial arrangement of a portion of these specimens, point very clearly to the genus *Dendya*, while the other characters exhibited by the sponge make it quite impossible to place it therein, at any rate as the genus is at present constituted. Another equally difficult point to determine is whether the *Dendya*-like characters are primitive or secondary, as the central gastral cavity, which is well marked in the young specimens, is completely obliterated in older individuals, while it is only in these latter that the radial arrangement of the Ascon-tubes becomes completely developed.

To place it in the genus *Dendya* would therefore necessitate a very considerable alteration in the accepted diagnosis of this genus; to erect a new genus for it seems also somewhat inadvisable, since the genus *Leucosolenia*, as diagnosed by DENDY and ROW (1913), will receive it without any alteration of the diagnosis. The genus contains forms with very varying canal systems; to add another type to the list will make but little difference, and it certainly seems a wiser procedure to wait until we know about the species to erect a special genus for it.

Skeleton.—The skeleton consists of triradiate spicules only, but of these two very distinct kinds can be distinguished, one being a perfectly regular triradiate, which occurs throughout the sponge in the walls of the Ascon-tubes, and the other a very characteristic "tripod" spicule, which only occurs on the outer surface. The dermal skeleton is thus very clearly differentiated from the central, but there is no variation whatsoever between the skeleton of the radially arranged

tubes and the skeleton of the clathroid portion of the sponge.

Owing to the considerable thickness of the wall of the tubes the spicules are arranged in several rather irregularly disposed layers. The skeleton of the dermal surface consists of a single layer of the tripod spicules on the surface itself, immediately beneath being a dense mass of the ordinary triradiates covering the ends of the radially arranged chambers, or, in specimens which have not reached that stage of development, the normal skeleton of the wall of the tubes.

Spicules. — The ordinary triradiate is quite regular in shape, being both equiangular and equiradiate. All the rays are cylindrical, rather slender, though stouter at the base than at any other point, and they taper gradually and uniformly then to a point near the apex. Here the tapering becomes much more abrupt and the end of the spicules is usually obtusely, or even bluntly pointed.

The average length of the rays is 100 μ, with a maximum of 110 μ, and the thickness of the rays at the base is usually 10 μ.

Very occasionally specimens can be found with an extremely rudimentary fourth ray present, but not in more than one in a thousand specimens.

Tripod spicules which cover the surface are very easily distinguished from the above both by their shape and by their much greater stoutness of ray. Seen in the facial plane, they are very markedly sagittal, with the paired rays frequently lying in the same straight line, the true oral angle being indicated only by a slight notch. Even when there is an obvious oral angle less than 180 degrees, the rays often immediately come to lie in a straight line, and then gradually and uniformly curve towards each other again, and away from the basal ray. Other spicules, however, can be found with the three angles at the centre very nearly equal, and sometimes even with the oral angle less than the other two, though this latter is very rare, and some of the spicules can only be classed as irregular. Seen in profile, the three rays form a tripod, with the centre steeply raised, while the distal ends of the rays are curved till they lie flat on the surface for some portion of their length.

Owing to the peculiar curvature of the rays, measurements of length are somewhat difficult to determine, and the following are taken in a straight line from the centre of the spicule to the tip. Basal

ray, 130–150 μ long and 30 μ thick at base; oral rays, 90–130 μ long and 30 μ thick at base.

All the rays are cylindrical, and taper faily uniformly from base to apex; frequently, however, the rays are somewhat irregular in outline. The rays are almost always quite blunt at their extremities.

Previously known Distribution.—S. W. coast of Australia (CARTER); Near Port Phillip Heads, Westernport (Victoria), Kent Islands (Bass Strait) (DENDY); Cook Strait (KIRK).

Localities and Register Nos. of Specimens.—Geraldton District (Station 31), AG_8, $AH_6\beta$, $AJ_3\gamma$, $AJ_8\delta$, $AJ_8\epsilon$, $Z_1\delta$, $Z\theta$; Fremantle Bay (Station 45), BG; Bunbury Bay (Station 56), $AZ_4\beta$.

3. **Leucosolenia coriacea** (MONTAGU)

Spongia coriacea, MONTAGU, 1818, p. 116.
Grantia coriacea, JOHNSTON, 1842, p, 183, Pl. XXI, Fig. 9.
Leucosolenia coriacea, BOWERBANK, 1864, Vol. II, p. 34; GRAY, J. E., 1867, p. 556; CARTER, 1877, p. 42; HANITSCH, 1895, p 206; BREITFUSS, 1897, p. 211; (3) 1898, p. 12; (7) 1898, p. 20; 1927, p. 28; DENDY, 1905, p 226, Pl. XIII, fig. 8; DENDY and ROW, 1913, p. 725.
Clathrina sulphurea, CARTER. 1871, p. 279.
Clathrina coriacea, RIDLEY, 1881, p. 132; MINCHIN, 1896, p. 359.
Ascetta coriacea HAECKEL, 1872, Bd. II, p. 24, Taf. 3, Taf. 5, Figs. 2a–2c; HANITSCH, 1890, p. 232; ARNESEN, 1900, p. 10.

Two small specimens have been assigned to this species, the identification having been determined solely on account of the character of the skeleton arrangement and spiculation in every instance, as both specimens were too small to enable one to judge satisfactorily of the character that the colony would assume when it grew larger, nor was either of the two large enough for successful detailed investigation.

In this regard it must be noted that the absence of large and therefore characteristic specimens of *Leucosolenia coriacea* renders it at least possible that the above individuals are really only very young forms of some other species, in which the distinctive characters of the species have not yet appeared, but the whole of the other species represented in the collection have such definite characters that this seems at least unlikely.

Previously known Distribution.—Cosmopolitan: Arctic Ocean; Atlantic Coast of Europe; Mediterranean Sea; Pacific Ocean; Indian

Ocean; West Australia, Fremantle.

Localities and Register Nos. of Specimens. — Geraldton District (Station 31), AAy; Shark's Bay District, B_2.

4. **Leucosolenia primordialis** (HAECKEL)

Acetta primordialis, HAECKEL, 1872, p. 16, Taf. 1, 2; Taf. 5, Figs. 1 a–1 i; VON LENDENFELD, 1891, p. 11, Taf. VIII, Fig. 1; Taf. IX, Figs. 23–26.
Clathrina primordialis, MINCHIN, 1896, p. 359; CARTER, 1896, p. 510.
Leucosolenia primordialis, LACKSCHEWITSCH, 1886, p. 299; BREITFUSS, 1897, p. 212; (3) 1898, p. 12; (7) 1898, p. 21; DENDY and ROW, 1913, p. 726.

Only a single specimen could be assigned to this very well known species, which might have been expected to occur in much greater numbers. The example in question is of rather small size, approximately flask-shaped, and apparently with a single osculum at the small end. The larger end, which is flattened and considerably damaged, is undoubtedly the base, by which it was attached to some foreign body, though no portion of its support still remains. It consists of a lax mass of fairly large tubes which branch and anastomose freely to form the usual clathrous colony, and whose average individual diameter is about 0.3 mm. The whole colony measures about 15 mm. high, and 5 mm. across at the base. In the general structure of the tubes, and in the arrangement of its skeleton and spiculation it corresponds very closely indeed to HAECKEL's original description.

Previously known Distribution. — Cosmopolitan: Mediterranean Sea; Atlantic Ocean, Red Sea, Indian Ocean, Coast of Australia, Pacific Ocean.

Locality and Register No. of Specimen. — Shark's Bay (Station 3), AU_1.

5. **Leucosolenia psammophila,** n. sp.

(Pl. XIX, Fig. 1; Text-fig. 1)

This somewhat unsatisfactory species is represented in the collection by a single large individual, which is flat and biscuit-like in shape, and of circular outline (Spec. AO., Pl. XIX, Fig. 1). The complete specimen measures 38 mm. in diameter across the top, and is 8 mm. thick. It consists of a dense mass of small and thick-walled tubes, and the whole sponge is heavily loaded with enormous quantities of

sand, whence is derived its specific name.

The specimen was not attached to any foreign objects, nor was there any mark on the surface where such attachment might have been, and this, together with the presence of the sand in the sponge, makes it seem likely that the species lives free on a sandy bottom, probably more or less completely buried.

No oscula were distinguishable on the sponge-surface, but the reticulation of tubes forms a very definite "pseudoderm", and the oscula may have been merely overlooked owing to their similarity to the "pseudopores", or they may have completely closed when preserved in spirit. The "pseudoderm" is pierced by considerable numbers of very small "pseudopores", which do not measure more than 0.3 mm. in diameter as a general rule, though of course larger examples can occasionally be found. There is no "pseudogaster" or "pseudosculum".

The colour of the sponge in spirit was yellowish grey, appearing more clearly yellow according as more sand was removed. When dissolved in caustic potash (for spicule preparation), it caused the fluid to become a clear golden yellow, quite different to the previous colour of the specimen.

The texture of the sponge is fairly fine, though brittle, and easily broken under pressure and rather liable to crumble. The central parts of the sponge were almost completely filled with tissue or sand, there being practically no interspaces until the sand was washed out.

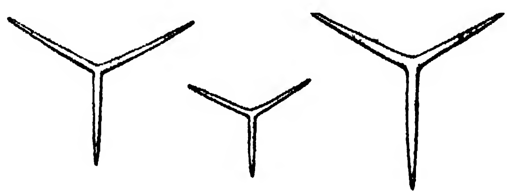
These rather curious characteristics render it at least possible that the specimen represents an abnormal condition; in several ways it seems to be fairly similar to *Leucosolenia coriacea* (MONTAGU), especially in the form of the spicules, and in fact, at first we had decided to include it in that species but further consideration has caused us to think it advisable to erect it into a separate species, in view of the undoubted differences that do occur between the two, which, if they are normal, would remove it immediately from *L. coriacea*. Presumably, if the sponge is actually abnormal, the abnormalities must have been produced by crushing or possibly continued pressure, but against this is the probability that the sponge lived free in sand, as stated above, a position in which crushing is very unlikely.

Structures. — The canal system proved to be rather difficult to investigate, owing to the presence of the large quantities of sand

within the sponge, which very seriously interfered with section cutting. The principal characteristic of the canal system that could be made out was a great increase in the thickness of the mesogloea, so that the walls of the tube were at least as thick as the diameter of the cavity of the tube, and sometimes even exceeded this. Also the tubes themselves were frequently choked up with debris so that the structure, presuming that there was a definite structure present, could not be made out. Otherwise the canal system is not specially noteworthy.

The whole skeleton is composed of triradiates, all similar and all small. They occur in enormous numbers throughout the sponge, lying many layers deep in the mesogloea of the tube-wall; they are quite unoriented, and there is no difference between the spicules on the outside of the sponge and those within it.

Spicules (Text-fig. 1). — Spicules are all of the same kind, and



Text-fig. 1. *Leucosolenia psammophila*, n. sp. Triradiates of Ascon-tubes. (All ×110)

are perfectly regular in shape, with cylindrical rays slightly thicker at the base than at any other point. From the base the rays taper very slightly for about seven-eights of their length, while in the distal portion the diameter very rapidly diminishes to a somewhat blunt point. In a few cases spicules occur with sharply pointed rays, but these are very rare indeed. The average length of the rays of a fully grown spicule is 140 μ, and their thickness at the base 13 μ, but a few specimens seem to exceed these measurements and the maximum length is not less than 160 μ. Enormous numbers of smaller spicules are present in all parts of the sponge, but these are all apparently young forms, as all intermediate sizes may be found, nor is one size more frequently met with than another. In the very young examples the ends of the rays are usually sharply pointed.

Locality and Register No. of Specimen.—Fremantle District (Station 35), AO.

6. Leucosolenia stipitata Dendy

Leucosolenia stipitata Dendy, 1891, p. 51, Pl. I. Figs. 4, 5, 6; Pl. IV, Fig. 2; Pl. IX, Fig. 5; Dendy and Row, 1913, p. 727.

A single specimen of this species occurs in the collection, and while the individuals of this species are according to Dendy's original description always small, the one now obtained is smaller even than those from Victoria. We have, however, been able to examine some of the type specimens, and have compared them carefully with this one, both as to general appearance and skeleton and spiculation, and the agreement is so close in all essential details that we think there can be no doubt whatsoever that the identification is correct. The specimen now under consideration consists of a small clathrous mass of anastomosing Ascon-tubes, situated at the summit of a short stalk, which is itself an Ascon-tube, the whole person being about 5 mm. in height and 3 mm. in diameter through the head, while the diameter of the stalk does not exceed 1.5 mm. At the summit of the colony is a small single osculum, a point upon which some stress was laid by Dendy in his original description of the species.

The skeleton is exactly similar to that of the type specimen, though some of the spicules seem to be slightly more sagittal in shape in the present case than in the type, and to have a slightly larger oral angle between the paired rays; but by far the larger proportion of the spicules agree in all details with Dendy's description. Further, the same difference between the spicules on the surface of the sponge and those in the interior was clearly noticeable in this specimen as well. The measurements of the spicules correspond exactly. We found it impossible to determine the position of the nucleus in the collared cells satisfactorily.

Previously known Distribution.—Near Port Phillip Heads (Dendy).

Locality and Register No. of Specimen.—Geraldton District (Station 31), Z17.

7. **Leucosolenia vitraea**, n. sp.

(Pl. XIX, Fig. 2; Text-fig. 2)

This species is represented in the collection by a single specimen only, in the form of a rather elongated spherical cushion, measuring 15 mm. long, 10 mm. wide, and 10 mm. high, growing on the stem of a water-plant (Pl. XIX, Fig. 2). The whole sponge consists of an elaborate network of Ascon-tubes, which branch and anastomose repeatedly. The sponge-surface thus appears to be pierced by a very large number of circular holes, which are really the gaps between the Ascon-tubes and which average 0.5–1 mm. in diameter. On cutting away a portion of the colony, it is seen that the interior of the sponge presents exactly the same appearance as the outside, so that there cannot be said to be any true pseudoderm, though, as we shall see presently, there is a definite "pseudocortical" skeleton in the walls of the outer tubes.

No oscula could be distinguished on the sponge-surface, either owing to the contraction of the sponge having completely closed them, or to their being indistinguishable from the gaps between the Ascon-tubes.

The colour of the sponge is dead white and it is so glass-like as to be almost transparent, whence the specific name. In texture it is soft, but fairly tough and not very easily torn, principally owing to the presence of the special "pseudocortical" skeleton. Its surface is perfectly smooth.

Structure. — For some reason or other this sponge was in a much worse state of preservation than most of the others in the collection, and but little could be made out concerning the canal system. The cells were only distinguishable in small patches here and there and their true distribution could not be ascertained. It is of course possible that they are only present in these rare patches, but this seems very unlikely, and I think that it is much more probable that the dense "pseudocortical" skeleton prevented the preservation fluid from penetraiting the interior of the sponge, and thus the patches of collared cells now visible would be those round the prosopyles, the only spots where the spirit could reach them quickly enough to prevent maceration. The general arrangement of the canal system does not call for

any special comment.

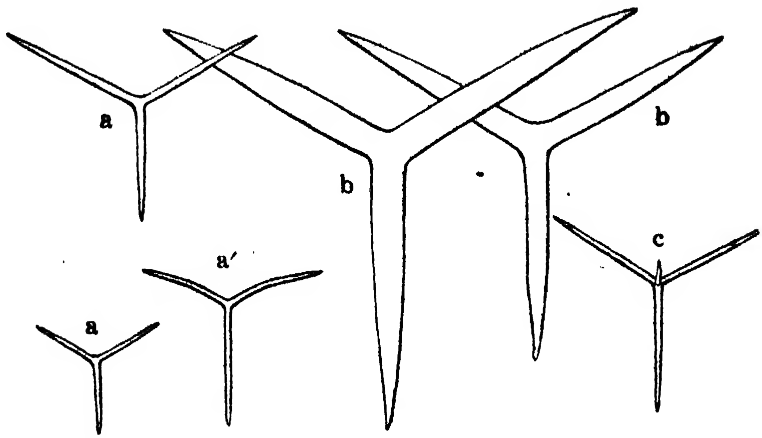
The skeleton consists almost solely of triradiates, with a very occasional quadriradiate intermingled with them from time to time.

Two very different types of triradiate, however, occur, one, the larger, being confined to the outermost parts of the sponge-colony, while the smaller forms the whole of the skeleton of the rest of the sponge. These latter are slender, delicate spicules, not more than half the size of the "pseudocortical" spicules, which form a definite and dense layer covering the whole of the outer surface of the exterior tubes. In this way these tubes have developed a special skeleton of their own, which we have called a "pseudocortical" skeleton; it must, however be remembered that this special skeleton is developed strictly in the walls of the Ascon-tubes, and not in a special development of mesogloeal tissue, as it is in those sponges among the more highly specialized members of the group which possess a true cortex, such as *Grantia*, for example. Immediately beneath this special layer of large triradiates comes a layer of the ordinary small triradiates, forming, as it were the true skeleton of the tube wall. Neither the large nor the small triradiates are definitely oriented in any part of the sponge.

Quadriradiates, when they occur, are merely triradiates to which an apical ray has been added; they are not to be distinguished from them in any other way, and both large and small triradiates can be found possessing this additional ray.

Spicules (Text-fig. 2). — Small triradiates (a). — These are in almost all cases quite straight, cylindrical rays which taper uniformly from their base almost right up to the apex, the tapering being very slightly more abrupt for about the distal tenth of their length. Very rarely spicules are found with two of the rays slightly curved, so that the spicules come to present a faintly alate appearance (a'). The average length of the fully formed spicule is 135 μ and its diameter at the base, where it is thickest, averages 10 μ, but specimens can occasionally be found which considerably exceed these measurements, some of them attaining a maximum length of 160 μ, and a diameter of 12 μ.

Large triradiates (b). — Like the small triadiates, these spicules also are regular, equiangular and equiradiate, but they can be immediately distinguished by their much larger size. They show somewhat greater range of measurement than do the small spicules, ranging



Text-fig. 2. *Leucosolenia vitraea*, n. sp.
a, Small triradiates. a', Small alate triradiate. b, Large triradiates. c, Quadriradiate. (All ×110)

from twice to three times as long and wide as the latter. All the rays are quite straight and cylindrical being almost the same diameter for the proximal two-thirds of their length. The distal third is tapered much more rapidly up to a point close to the apex of the spicule, which is, however, usually blunt and even rounded. The rays are 248–370 μ long, and 25–31 μ thick at the base.

Quadriradiates (c). — As stated above, the only difference between these spicules and the triradiates is the presence of a small apical ray, which very rarely exceeds 50 μ in length and 10 μ in thickness of base. These apical rays may be developed on large and small triradiates alike.

Locality and Register No. of Specimen. — Albany District (Station 64), B*p*.

Family **Leucascidae** Dendy

Genus Leucascus Dendy

8. **Leucascus simplex** Dendy

Leucascus simplex, Dendy, 1892. p. 77; 1913, p. 9, Pl. I, fig. 5; Pl. IV, fig; 1; Kirk, 1897, p. 313; Dendy and Row, 1913. p. 731.

This species is represented in the collection by five comparatively

large specimens and one very small specimen. All are irregular and massive and form spreading crusts of greater or less extent attached to the stems of sea-weeds. The largest crust measures about 30 mm. long and 15 mm. wide, but is very thin, though in most of the other specimens the sponge attains a thickness of about 5 mm. All the specimens possess several oscula scattered about indiscriminately over the surface.

The species has been very fully described by DENDY (1892 and 1913), so that no further details are necessary.

Previously known Distribution. — Near Port Phillip Heads; Bass Straits and Watson's Bay, Port Jakson (DENDY, 1892); New Zealand (KIRK, 1897); Providence, Indian Ocean (DENDY, 1913).

Localities and Register Nos. of Specimens. — Shark's Bay District (Station 15), M; Geraldton District (Station 31) ACβ; Fremantle District (Station 34), AM_1, AM_2, AU_2; Bunbury District (Station 56), $AZ_1\beta$.

9. Leucascus clavatus DENDY

Leucascus clavatus, DENDY, 1892, p. 78; DENDY and ROW, 1913, p. 731; BRØNDSTED, 1926, p. 300.

A single extremely small specimen was assigned to this species on account of the character and shape of the oxea. The specimen is almost in the Olynthus condition, and it is with considerable hesitation that we have ventured to assign any definite name to it. Certainly it would be impossible to say for certain that the identification was a correct one, but the oxea are in this species of very striking and peculiar shape, and no other species is known, so far as we can determine, with oxea exactly similar. It seems very possible, then, at any rate that the specimen may be a very young individual of this species, and as such we have considered it.

Previously known Distribution. — Near Port Phillip Heads (DENDY); Halfmoon Bay, Stewart Island N. Z. (BRØNDSTED).

Locality and Register No. of Specimen. — Geraldton District (Station 31), $Z_1\epsilon$.

Genus LEUCETTA HAECKEL (emend.)

10. **Leucetta insignis,** n. sp.

(Pl. XIX, Fig. 3; Text-fig. 3)

One specimen only of this species occurs in the collection, and this specimen itself is only a fragment of a probably much larger sponge (Spec. AE from Station 31). It now consists of a massive, approximately square piece, measuring about 30 mm. by 35 mm. showing a large area at each end where the rest of the sponge has broken away, and varying in height from 15 mm. to 20 mm. Apparently the perfect sponge takes the form of an elongated crust, whose upper surface is traversed by a series of more or less parallel ridges, and it probably presents a more or less close resemblance to *Leucetta prolifera* as regards external appearance.

The specimen now being described possesses parts of three of these ridges, and on their summit occur the oscula, which number 10 in all. Like the sponge, two of the ridges are incomplete at each end. Each osculum (except two), is about 2 mm. in diameter, and on looking down it into the interior of the sponge there can be seen the opening of numerous exhalant canals, which approach from all directions to meet together immediately below the osculum. Two of the oscula, however, are much smaller, probably due to contraction when the sponge was preserved, as they only measure 0.5 mm. in diameter. The sponge is greyish white in colour, its surface is quite smooth, and its texture firm though easily cut.

Structure. — On the surface of the sponge there is an extremely thin and delicate dermal membrane, pierced by multitudes of minute pores, which covers over a series of irregular subdermal cavities from which inhalant canals run down into the interior of the sponge. These cavities and canals are sometimes quite large lacunae. The canal system is of leuconoid type but the flagellate chambers are more or less elongated and are arranged under the sylleibid condition, approaching a condition with elongated and more or less radially arranged flagellate chambers as in the genus *Leucascus*. The position of the nucleus in the collared cells is basal.

The main mass of the skeleton is composed of small triradiates and quadriradiates, which occur in great numbers and fill up the

sponge body. The spicules lie entirely without orientation in the sponge, and both kinds of spicules are mixed up together quite indiscriminately, and occur in all parts. The quadriradiates are frequently found in the walls of the exhalant canals with their apical rays projecting into their cavity.

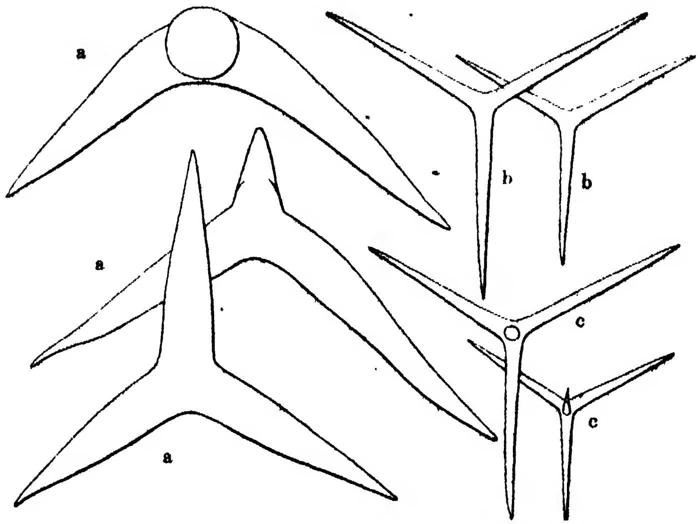
On the dermal surface of the sponge there occur triradiates of very large size, appearing almost colossal in comparison with other spicules of the sponge. They are only sparsely scattered over the surface, but form undoubtedly the begining of a special cortical skeleton, such as we see developed to a very high extent in many species of the family Leucaltidae. A considerable extent of the sponge surface was examined, but no specimen of these large triradiates was found possessing an apical ray.

There is no special oscular skeleton.

Spicules (Text-fig. 3). — Large dermal triradiates (a) are markedly of tripod shape, and thus form obvious prominences on the surface of the sponge. They are probably all quite regular, though when seen in boiled-out preparations they frequently appear to be more or less sagittal, owing to the fact that tripod spicules always appear distorted unless seen in the actual facial plane. They possess very stout rays, which are usually quite straight, though sometime slightly irregular in outline, and which are of the same diameter for about half their length, sometimes even being slightly thicker in the middle than at the base, and thence sharply tapering to the very blunt point. Rays measured 200–260 μ in length and 30–60 μ in thickness of base.

Smaller triradiates which form the main mass of the skeleton (b) are quite regular, equiangular and equiradiate, with cylindrical straight rays, which taper uniformly from the base close up to the apex, though for the distal one-tenth of the length of the ray the diminution of thickness is somewhat more accentuated. The apex itself is sharply pointed in almost every case, but occasional spicules can be found in which the rays end bluntly. The rays are 70–130 μ long, and 10–16 μ thick at the base.

Quadriradiates of the main skeleton (c) are exactly similar in size and appearance to the triradiates of the same, only differing from them in the presence of an apical ray. The apical ray is always very slender and is uniformly tapered from the base to the sharp point.



Text-fig. 3. *Leucetta insignis*, n. sp.
a, Large dermal triradiates seen from various directions. b, Triradiates of the main skeleton. c, Quadriradiates of the same. (All ×200)

It is usually straight but frequently somewhat bent or even wavy in shape. It is 30–40 μ long and 4–6 μ thick at the base.

Quadriradiates of the exhalant canals are quite similar to the above, differing only in having longer and stouter apical rays measuring 40–170 μ long and 6–12 μ thick at the base.

Locality and Register No. of Specimen.—Geraldton District (Station 31), AE.

11. Leucetta microraphis HAECKEL

Leucetta primigenia, var. *microraphis*, HAECKEL, 1872, Vol. II, p. 119, Taf. 21, Figs. 10–17.
Leucetta microraphis, RIDLEY, 1884, p. 482; VON LENDENFELD, 1885, p. 1117; DENDY and ROW, 1913, p. 734; DENDY and FREDERICK, 1924, p. 482.
Leuconia dura, POLÉJAEFF, 1888, p. 65.
Leucandra microraphis, DENDY, 1892, p. 104.
Leucandra primigenea var. *microraphis*, ROW, 1909, p. 186.

This extremely well-known species is represented in the collection by numerous specimens, one or two of them being very large, and most of the others seeming to be fragements broken off still larger

individuals. All are typical, irregular masses which frequently appear to take the form of more or less clearly defined ridges and prominences, and usually with very numerous oscula, though these are not visible in all the specimens. This species is so well known that there is no need to give any further description of it.

Previously known Distribution. — Australia? (HAECKEL); North Coast of Australia, Torres Straits (RIDLEY, POLÉJAEFF); East Coast of Australia, Port Jackson; South Coast of Australia, Near Port Phillip Heads (LENDENFELD, DENDY); Red Sea (ROW); Off Bermudas (POLÉJAEFF); Abrolhos Islands, Western Australia (DENDY and FREDERICK),

Localities and Register Nos. of Specimens. — Shark's Bay District (Station 1 and 15), C_1E_1, E_2, O; Geraldton District (Station 32), AL_1, AL_2, AL_3, AL_4, AL_5; Bunbury District (Station 56), BB.

12. Leucetta prolifera (CARTER)

Teichonella prolifera, CARTER, 1878, pp. 35–40, Pl. II, figs. 1–5; DENDY, 1891, Pl. I, fig. 6.
Leucilla prolifera, DENDY, 1892, p. 115.

This species is represented by four specimens in the collection. They differ somewhat in size from each other, but are nearly similar in both the external appearance and the internal structure.

The description of the species is fully given by CARTER, therefore we do not feel the necessity to add further details to it.

Previously known Distribution. — Near Port Phillip Heads and Fremantle District (CARTER).

Localities and Register Nos. of Specimens. — Geraldton District (Station 31), AC; Fremantle District (Station 43), AV_1, AV_2; Albany District (Station 64), BR.

13. Leucetta infrequens, n. sp.

(Pl. XIX, Fig. 4; Text-fig. 4)

In the collection there exist six specimens of this new species which were obtained at Station 43 in the Femantle District.

The specimen (Spec. No. AT_1; Pl. XIX, Fig. 4), which served as the type, forms an irregularly shaped mass of rather small size measur-

ing about 10 mm. in height and about 10 mm. in greatest breadth. The surface is uneven and provided with two small naked oscula, both measuring about 0.5 mm. in diameter. The colour in alcohol is greyish and the texture is firm and compact.

Structure. — The canal system is of the leuconoid type. The flagellated chambers which are rather closely packed in the chamber layer and among inhalant and exhalant canal systems are oval or nearly spherical with maximum diameter of 130 μ. The collared cells are rather thinly distributed in the wall of the flagellated chambers.

The skeleton of the dermal cortex is rather poorly developed and is not clearly distinguished from that of the chamber layer. It is made up chiefly of small triradiates placed tangentially in several confused layers and there may be added some larger triradiates disposed tangentially. The skeleton of the chamber layer consists in the main of small triradiates, which are thickly set together without any definite order.

The oscular margin is deprived of any peculiar skeleton.

Spicules (Text-fig. 4). — Larger dermal triradiates (a) equiradiate and equiangular. All rays straight, gradually and sharply pointed, 300–440 μ long and 40–70 μ thick at base.

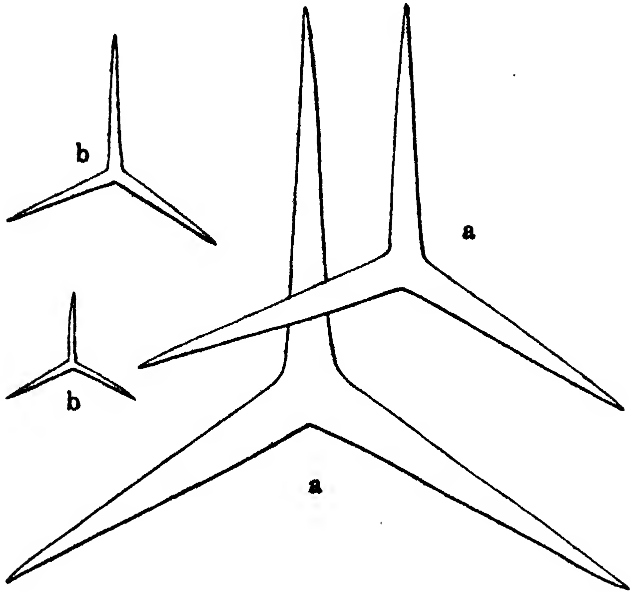
Smaller dermal triradiates (b) equiradiate and equiangular. All rays straight and gradually sharp-pointed, measuring 80–130 μ long by 10–20 μ thick at the base.

Triradiates of the chamber layer exactly the same as the smaller triradiates of the dermal cortex.

Remarks. — This species closely resembles *Leucetta chagosensis* DENDY[1] but may be distinguished from it in not having a distinct system of subdermal cavities which lie in the rather thick gelatinous ectosome and in the absence of smaller oscular triradiates with two of the rays bent sharply back near their bases until they come to extend nearly at right angles to the third ray.

Locality and Register Nos. of Specimens. — Fremantle District (Station 43), AT_1, AT_3, AT_4, AT_5, AT_6, AT_7.

[1] *Leucetta chagosensis*, DENDY, 1913, p. 10. Pl. 1, Fig. 6; Pl. 4, Fig. 2.



Text-fig. 4. *Leucetta infrequens*, n. sp.
a, Larger dermal triradiates. b, Smaller dermal triradiates. (All ×100)

14. **Leucetta expansa**, n. sp.

(Pl. XIX, Fig. 5; Text-fig. 5)

This new species is represented in the collection by two specimens which came from Station 25 in Shark's Bay.

The larger specimen (Spec. No. Y_3) is taken as the type on which to base further descriptions and is represented in Plate XIX, Fig. 5.

The external form is massive and irregular, the surface being provided with scattered oscula of various sizes, the largest measuring about 4 mm. in diameter. It measures about 35 mm. in length by 25 mm. in breadth and 20 mm. in greatest thickness.

The colour in alcohol is brownish, probably stained by other substances. The texture is fairly compact and firm but friable.

The canal system is typically leuconoid. The flagellate chambers are faily thickly packed in the chamber layer. Each of the oscula leads into an exhalant canal which is first very thick but becomes gradually thinner as it penetrates deeper into the sponge body, by

sending off on its way many smaller branches distributing among the flagellate chambers. There exists no common central gastral cavity.

The skeleton of the dermal cortex consists chiefly of several confused layers of large and small triradiates placed tangentially. To these spicules may be added a large number of microxea in dense and irregular distribution.

The chamber layer contains the skeleton consisting of large triradiates thickly and irregularly scattered. The wall of the larger exhalant canals are sustained by small quadriradiates with their apical rays projecting into the canal.

Spicules (Text-fig. 5). — Large dermal oxea (a) equiangular and approximately equiradiate. All rays stout, tapering gradually to fairly sharp points and measuring 300–500 μ long by 40–60 μ thick.

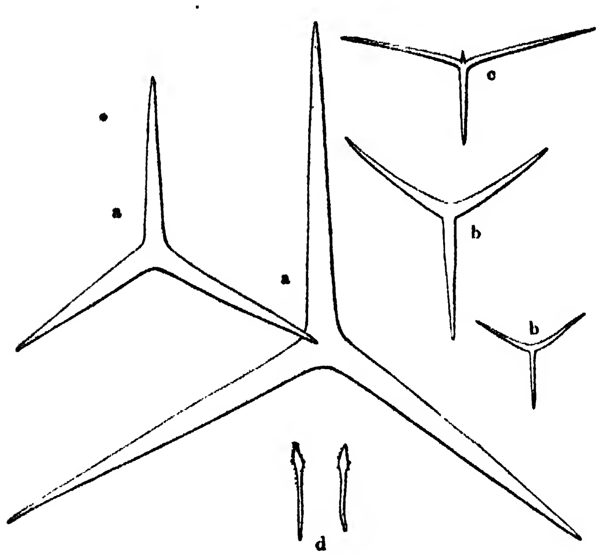
Small dermal triradiates (b) slightly sagittal. All rays are of nearly equal length and of equal thickness, tapering gradually to fairly sharp points. Basal ray straight, 100–230 μ long and 14–20 μ thick at base. Paired rays slightly curved forwards making an oral angle wider than the paired angles, 100–250 μ long and 14–20 μ thick at the base.

Large triradiates of the chamber layer are exactly similar to those of the dermal cortex.

Quadriradiates of the larger exhalant canals (c) are strongly sagittal. All rays slender, nearly equally thick through their greater length. Basal ray straight, distinctly shorter than paired rays, sharply pointed at end. Paired rays very widely diverging, nearly straight except for a slight curvature near the base. Apical ray shorter and thinner than either the paired rays or basal ray. It is slightly curved. In a typical case the basal ray measures about 150 μ by 16 μ; the paired rays about 250 μ by 16 μ, and the apical ray about 70 μ by 8 μ.

Microxea (d) are almost straight, proximally tapering to a sharp point, distally terminating with a lance head which is provided with a sharp apex. The distal half of the spicule, especially the head, is covered with very fine spines. These spicules are about 40 μ in length and 4 μ in thickness.

Remarks. — This species can not be identified with any species already known of the genus. The presence of microxea and not of large oxea appears to be characteristic to it.



Text-fig. 5. *Leucetta expansa*, n. sp.
a, Large dermal triradiates. b, Small dermal triradiates. c, Quadriradiate of the larger exhalant canal. d, Dermal microxea (a–c ×60; d ×300)

Locality and Register Nos. of Specimens. — Shark's Bay (Station 25), Y_2, Y_3.

Family Leucaltidae

Genus LEUCETTUSA HAECKEL (emend.)

15. Leucettusa dictyogaster, n. sp.

(Pl. XIX, Fig. 6; Text-fig. 6)

This new species is represented by five specimens in the collection and they were all obtained at Station 56 in Bunbury Bay. To base the further description on, I have selected the largest specimen (Spec. No. BC) as the type and it is shown in Pl. XIX, Fig. 6.

It consists of two anastomosing tubes provided with a common osculum at the upper end. The surface is uneven showing some convexities and concavities, but is nearly smooth though it is finely punctate in appearance. The total length of the specimen is about 50 mm. and the breadth is about 32 mm. at the broadest part.

The osculum is oval with the larger diameter of 9 mm. and is

surrounded by a distinct collar 1.5 mm. high. Looking down the osculum into the interior of the sponge there can be seen the opening of numerous exhalant canals which are distributed on the wall of the rather shallow central gastral cavity. The colour in alcohol is greyish white and the texture is, in outer surface, fairly rigid but is soft inside.

Structure. — The canal system is of the leuconoid type. The wall of the sponge is composed of three distinct layers, namely, a dermal cortex, a chamber layer and a gastral cortex. The dermal cortex is nearly uniformly thick measuring about 1 mm. The chamber layer is of very variable thickness, even attaining a thickness of up to 10 mm. It is formed of trabeculae which bear the flagellate chambers and are separated by very wide, irregular exhalant lacunae. The flagellate chambers vary in form from oval to spherical with a diameter of 80–150 μ. The gastral cortex is very thin and membranous lying in the wall of the central gastral cavity which is rather narrow, being only about 10 mm. deep by 12 mm. broad.

The dermal cortex is furnished with a strongly developed cortical skeleton which is made up of tangential triradiates and microxea. The triradiates are arranged in several layers without any definite orientation but leaving some spaces in an irregular mesh-like manner for inhalant canals. The microxea occur chiefly in the outer part of the cortex and are rather thinly distributed. In regard to the orientation they are tangential; otherwise there exists no regularity.

The gastral cortex is provided with a skeleton formed of tangential quadriradiates in nearly a single layer with their apical ray projecting into the gastral cavity.

The thin oscular margin bears a special skeleton which contains some triradiates differing somewhat in shape from that of the dermal cortex.

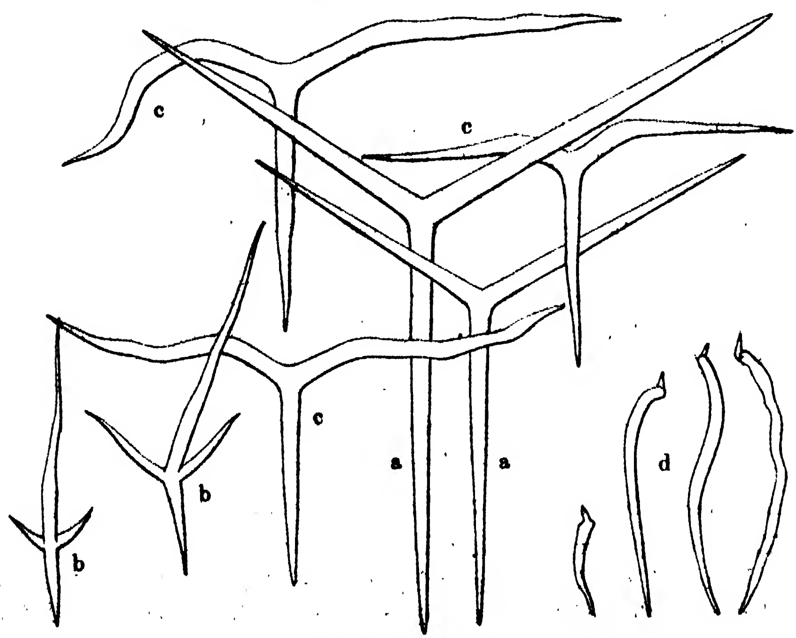
Spicules (Text-fig. 6). — Dermal triradiates (a) regular, rather slender-rayed. All rays straight and gradually sharply pointed, 380–580 μ long and 30–50 μ thick at the base.

Gastral quadriradiates (b) sagittal. Basal ray straight, broad in basal part but becoming narrower rather suddenly towards the sharply pointed end, 30-50 μ long by about 8 μ thick. Paired rays slightly shorter and thinner than basal ray, a little curved forwards in basal part and finely pointed at the end, 20–40 μ long and about 6 μ thick

at base. Apical ray very strongly developed, nearly equally thick as basal ray but exceedingly longer than the latter. It is somewhat crooked and very finely pointed at the end, 100–120 μ long by about 8 μ thick.

Triradiates of oscular margin (c) sagittal. All rays are nearly equally long and equally thick. Basal ray nearly straight, gradually and sharply pointed. Paired rays strongly divergent, showing an angular curvature at a short distance from the base, and either nearly straight or curved in distal part ending in a sharp point. In a typical example of the spicule the rays measured about 320 μ long by 30 μ thick.

Dermal microxea (d) cylindrical, more or less undulating, provided at one end with a short pointed head making an angle with the main body of the spicule, while the other end is solely sharp-pointed. As a whole, each spicule gives somewhat a snake-like appearance. They are 30–130 μ in length and 6–10 μ in thickness.



Text-fig. 6. *Leucettusa dictyogaster*, n. sp.
a, Large dermal triradiates. b, Gastral quadriradiates. c, Triradiates of the oscular margin. d, Dermal microxea. (a, c ×75; b, d ×300).

Remarks. — The name of the present species appeared first in the paper of DENDY and ROW, which was published in 1913. In that paper a very brief account of the canal system of the species was dealt with. But since that time no fuller description which is sufficient to define the species has been given till the present time.

It is not difficult to distinguish the present species from the other members of the same genus by the presence of characteristic microxea in the dermal cortex.

Locality and Register Nos. of Specimens. — Bunbury Bay (Station 56), BC, BD_1, BD_2, BD_3, BD_4.

Family **Sycettidae**

Genus SYCON RISSO (emend.)

16. Sycon boomerang DENDY

Sycon boomerang, DENDY, 1892, p. 82; 1893, pp. 169, 191, Pl. 10, figs. 7, 8; DENDY and ROW, 1913, p. 745.

We have identified a single specimen in the collection with this species.

It differs from the typical *Sycon boomerang* only in the much smaller size and in the absence of a narrow stalk.

The total height of the specimen is 15 mm., the greatest breadth being about 6 mm. The thickness of the sponge wall measured 2 mm. in the thickest part.

Previously known Distribution. — Near Port Phillip Heads (DENDY).

Locality and Register No. of Specimen. — Geraldton District (Station 31), AF.

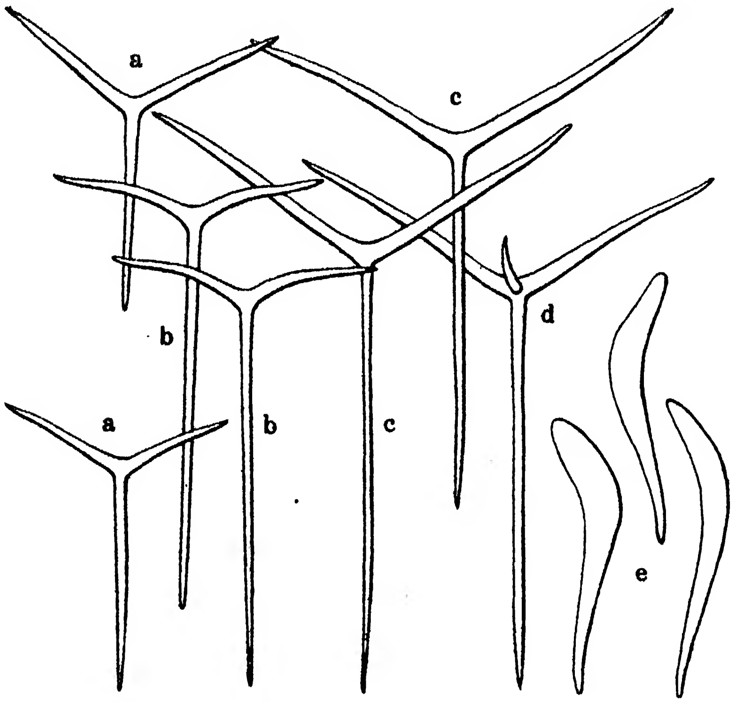
17. Sycon carteri DENDY

(Pl. XX, Fig. 7; Text-fig. 7)

Sycon carteri DENDY, 1892, p. 79; DENDY and ROW, 1913, p. 745.

There are present in the collection three large colonies of this very beautiful species, all growing on the stem of water-plants. In the lower portion of the colony there is much branching, but distally the tubes are undivided, thus producing the appearance of a mass of small individuals crowded together. A photograph of the external form of the largest colony (Spec. AX_9) is given in Pl. XX, Fig. 7.

This is one of the most primitive species of the genus *Sycon;* it is, in fact, very close indeed to *Sycetta*, for the flagellated chambers are short and wide, and their walls are but little fused together. In fact, many of the characters are quite free from their neighbours, and in surface view they can be seen standing out quite separately from the wall of the gastral cavity. The inhalant canals are large and numerous, but owing to the separation of the flagellated chambers, they are not clearly defined.



Text-fig. 7. *Sycon carteri* DENDY.
a, Tubar triradiates. b, Subgastral triradiates. c, Gastral triradiates. d, Gastral quadriradiate. e, Oxea. (All ×300)

The nucleus of the collared cells is apical in position.

No drawings of the individual spicules have ever been given, and we therefore append them here (Text-fig. 7), but in other details the description given of the species by its author (DENDY, 1892) is very full, and needs no amplification.

Previously known Distribution. — St. Vincent's Gulf, S. Australia (DENDY).

Localities and Register Nos. of Specimens. — Geraldton District (Station 31), AJ_1; Bunbury District (Station 56), AX_2, AY.

18. Sycon ciliatum (FABRICIUS)

Spongia ciliata, FABRICIUS, 1780, p. 448.
Grantia ciliata, JOHNSTON, 1842, p. 176, Pl. XX, Figs. 4, 5; Pl. XXI, Figs. 6, 7; GRAY, 1867, p. 554.
Sycum giganteum HAECKEL, 1870.
Sycocystis oviformis HAECKEL, 1870.
Sycodendrum ramosum HAECKEL, 1870.
Sycon ciliatum, SCHMIDT, 1870, p. 74; BREITFUSS, 1897, p, 216; (3) 1898, p. 18, Taf. I, Figs. 9–12; p. 23; 1927, p. 29; DENDY and ROW, 1913, p. 745.
Sycandra ciliata, HAECKEL, 1872, p. 296, Taf. 51, Figs. 1 a–t; Taf. 58, Fig. 9; ARNESEN, 1900, p. 16.

A single very small specimen has been assigned to this species.

Previously known Distribution. — Nearly cosmopolitan: Arctic Ocean; North Atlantic coast of Europe and North America; Adriatic Sea.

Locality and Register No. of Specimen. — Geraldton District (Station 31), ACδ.

19. Sycon enciferum DENDY
(Pl. XX, Fig. 8)

Sycon enciferum DENDY, 1892, p. 81; DENDY and ROW, 1913, p. 746.

This species is represented by a single specimen in the collection. A photograph of the external form of the specimen is given in Pl. XX, Fig. 8.

It is of an ovoid shape, measuring 12 mm. in length and 6 mm. in the greatest breadth. It is strongly compressed laterally and markedly constricted in the middle region. The osculum at the upper end is surrounded by a feebly developed collar about 0.4 mm. high.

The canal system and the skeletal arrangement, as well as the spiculation are exactly similar to those of the type specimen. We would only mention that the apical rays of the gastral quadriradiates seem to be slightly shorter and thinner in the present case than in the type specimen.

Previously known Distribution. — Near Port Phillip Heads (DENDY),

Locality and Register No. of Specimen. — Bunbury Bay (Station 56), X_1.

20. Sycon gelatinosum (BLAINVILLE)

Alcyoncellum gelatinosum, BLAINVILLE, 1834, p. 529; GRAY, 1867, p. 557.
Sycidium gelatinosum, HAECKEL, 1870, p. 245.
Sycandra alcyoncellum var. *gelatinosa*, HAECKEL, 1872, Bd. II, p. 334.
Sycandra arborea, HAECKEL, 1872, Bd. II, p. 331, Taf. 53, Figs. 1 a–t; Taf. 58, Fig. 7.
Sycon gelatinosum, DENDY, 1892, p. 83; BREITFUSS, 1897, p. 217; DENDY and ROW, 1913, p. 746; DENDY and FREDERICK, 1924, p. 483.

This well-known species is represented in the collection by 17 specimens, all of which are comparatively small. With the exception of two specimens, each of which forms a colony, the majority are of single person.

In the collection there are no such examples as were figured by HAECKEL in his monograph. There is, however, no doubt about the identification, they all being quite typical in both external appearance and internal structure, and thus agreeing in every detail with the specimens from Australia in the collection of the late Professor DENDY, with which they have been carefully compaired.

Previously known Distribution. — Indian Ocean; Java (HAECKEL); Australia; Port Jackson; Port Phillip; Watson's Bay; Bass Straits; St. Vincent's Gulf; Wooded Isle; Sandy Isle (various authors and collections); Albolhos Islands, Western Australia (DENDY and FREDERICK).

Localities and Register Nos. of Specimens. — Shark's Bay District (Station 3), F; (Station 7), A_{12}; (Station 8), Aq_{I}, Aq_{II}, Aq_{III}, A_{11}; (Station 10), A_{17}; (Station 12), H_1, R; (Station 14), J; (Station 15), K. (Station 25), X_7, X_8. Geraldton District (Station 31), AH_1, Z_1; (Station 32), AK_2. Bunbury District (Station 56), $A_5\gamma$.

21. Sycon lendenfeldi, n. sp.

(Pl. XX, Fig. 9; Text-fig. 8)

In 1885 VON LENDENFELD described a sponge, under the name of *Homoderma sycandra*, as the type and only known species of a new group of the Ascones (or Homoccela), characterized by a general

structure similar to that of *Sycon*, but with the central cavity lined throughout by collared cells. He emphasised with considerable care the fact that this distribution of the collared cells made it necessary to place the sponge in the section Homocoela, (if then existent diagnoses were to be retained), and since he himself considered the "Homodermic character more important than the Asconic", he was bound to separate his species very widely indeed from *Sycon*. As the sponge was also obviously very different from any previously known Homocoele species, he was obliged to errect a new family for its reception.

DENDY (1891), in his Monograph of the Victorian Sponges, Part I, was inclined to accept the author's position for the species, but stated that he considered that the characters of the sponge needed re-investigation, as the publication was somewhat scanty in view of the great peculiarities stated to occur in its structure.

Since that time we have come to consider the line of demarcation much less definite between the Homocoele and Heterocoele sponges than was formerly considered to be the case, and, as stated briefly in their work on the calcareous sponges, (DENDY and ROW, 1913), Professors DENDY and ROW no longer consider *Homoderma sycandra* to be anything but a somewhat aberrant *Sycon*. Then, however, the matter was only very cursorily referred to, and now it seems advisable, in view of the presence in the collection now being reported on of a very similar species, to restate the considerations which led to the relegation of VON LENDENFELD's species to the genus *Sycon*.

Firstly, the occurrence of collared cells in the central gastral cavity of Heterocoele sponges is not merely no impossibility, but actually occurs in the life of every individual, at any rate presumably, for all spongologists now consider that all calcareous sponges start their independent existence in the form of an "Olynthus", and at that stage the whole of the gastral cavity is lined by collared cells. Of course, VON LENDENFELD showed conclusively that his sponge was not a young individual, but definitely adult, as far as reproduction was concerned, but there was no certain evidence to show that the sponge had really reached its full growth, even though it was sexually mature. Even supposing, however, that the sponge was fully adult in every way, and that no further changes were to be looked for during the

remainder of its life, there is yet no question of the presence of a new character, but merely the existence in the adult individuals of a character present in them while young. And to show that even this persistence is not really extraordinary or unusual, we need only refer to the well known fact that in several of the simpler Sycons collared cells are known to occur lining that part of the gastral cavity above the topmost row of flagellate chambers, and just below the oscular rim. As far as collared cells are concerned, therefore, the difference between von Lendenfeld's *Homoderma* and *Sycon* is merely that they persist more in the gastral cavity in the former case than they ever do in the latter, and is not a radical difference of principle at all.

Secondly, when we come to compare the other features of *Homoderma* and *Sycon*, we fined that almost all the more important ones are identical in the two genera. For instance, the general arrangement of the canal system is identical as is also the skeleton arrangement. And the skeleton is, as in all Syconoid sponges, of considerable complexity and specialization. There is a definite gastral skeleton, a complex tubar skeleton, and a similar tuft of oxea at the distal ends of the chambers in each case, the principal types of spicule occurring in various parts of the sponge are almost exactly comparable, (if anything, *Homoderma* is provided with a more elaborate spiculation that most Sycons), the external forms of the two genera are identical, in fact, the only difference is that, already referred to, of the distribution of the collared cells.

The only other character distinguishing *Homoderma* from *Sycon*, is the presence in the former of a creeping stolon, but although this is an unusual feature to find in a *Sycon*, it is by no means incompatible with our knowledge of Syconoid sponges, and on the whole *Homoderma* is nothing but a somewhat primitive *Sycon*, without any characters sufficiently distinctive to warrant even generic rank.

In the present collection very numerous specimens occur of another species of *Sycon* which show the same persistence of the collared cells in the central gastral cavity, and we have therefore named it after the author of *Homoderma sycandra*. Between *Sycon sycandra* and *Sycon lendenfeldi* there are, however, several distinguishing points, such as the larger size of the individual, the absence of stolon, the presence of a much more obvious and better defined stalk in the

latter, and many skeletal spicular differences. Numerous differences of a less important type also occur, as will be seen from the description of *S. lendenfeldi* below.

The largest specimens are about 20 mm. high, the average height being approximately 15 mm., of which 7 or 8 mm. is occupied by the stalk. The average diameter of the sponge is 2 mm. with 2.5 mm. as maximum, and the diameter of the stalk is usually about 0.5 mm. An oscular fringe 1 mm. to 2 mm. high is present, surrounding a terminal osculum 1 mm. or thereabout in diameter.

The various individuals often grow together in groups, sometimes connected by their stalks, but there is never a creeping stolon. Most of the specimens in the collection are unattached, but one or two are still attached to water-plants. Owing to the fact that the dermal tufts of oxea tend to gather large quantities of debris about the surface of the sponge, the colour of most of the specimens is rather a dirty yellow, or yellowish white, but one or two of the individuals have apparently been situated in a position where they did not aquire this coat of debris, and they are quite white. The stalk is always perfectly white. In texture the sponge is always very delicate and fragile, due to the comparative thinness of the sponge-wall.

The sponge surface is finely, but very densely hispid; the stalk is also slightly hispid, but the hispidation in this case is so fine as not to be visible, without a lense. A photograph of the external form of the specimen AS_2 is given in Pl. XX, Fig. 9.

Structure. — There is a large central gastral cavity measuring from 0.8 mm. to 1 mm. in diameter, into which from 30 to 40 rows of short, conical flagellated chambers open. At the summit of the sponge is a single wide osculum, as wide, or even wider than the gastral cavity itself. The flagellated chambers are of rather irregular shape, and are irregularly arranged; they measure about 0.6 mm. to 0.9 mm. in length, and 0.2 mm. to 0.3 mm. in diameter. At the points where their sides come in contact they are fused together, but there is no dermal membrane covering over the inhalant canals. Distally, each chamber ends in a more or less elongated cone, quite unconnected to the neighbouring chambers.

There is a definite oscular rim extending 0.6 mm. beyond the topmost row of flagellated chambers. The stalk is hollow, its cavity

extending throughout its length, and surrounded by very thick walls, so that it does not measure more than 0.15 mm. in diameter at any point.

Collared cells line the whole of the oscular rim and the cavity of of the stalk, and they also occur scattered about in groups throughout the gastral cavity, between the openings of the flagellated chambers, but these groups are very variable both in their number and extent, though they have been found in every specimen examined. It will be seen from this that the persistence of those cells in the gastral cavity is not so complete as in *Sycon sycandra*, so that this species forms a connecting link between that and the typical Sycons.

Inhalant canals of irregular shape and disposition occur between the flagellated chambers. They are frequently comparatively large, and often of triangular section.

The flagellated chambers are not provided with difinite exhalant canals, but the collared cells extend right up to the mouth of the chamber, which is very wide.

The nuclei of the collared cells are apical in position.

Surrounding the osculum is a prominent fringe of oxea, in which the spicules are of two quite distinct kinds. Those composing the inner ring are long, silky and hair-like, and they are so set in the oscular rim that they do not diverge appreciably from each other, but form a fairly well defined tube of the same diameter at the osculum itself. Outside these there occurs another row in which the oxea are much stouter and shorter, and more sparsely distributed, and in which they are set much more obliquely, so that they diverge widely. Their proximal ends lie deeply embedded in the sponge tissue.

Immediately below these oxea occur two distinct bands of quadriradiates, each band consisting of three or four rows of spicules close together, so that the bands occupy but a very short region of the oscular rim. The two bands are quite distinct, being separated from each other by a distance of 0.3 mm. The spicules in these bands are all oriented in the usual way, with the two oral rays toward the osculum, and encircling the gastral cavity, the basal ray directed toward the base of the sponge, and the apical ray pointing into the gastral cavity. They are quite different in both size and shape from the gastral quadriradiates in the rest of the sponge.

Below these quadriradiates the oscular rim is provided with a horizontal oscular collar or "Corona", formed of small slender oxea arranged in a dense but thin fringe. These oxea are much smaller than the others occurring in the oscular region of the sponge.

Below these, again, comes another layer of quadriradiates, this time evenly and sparsely scattered over the whole of the wall. These are exactly similar to the quadriradiates found lining the gastral cavity throughout the sponge.

There is a thin gastral cortex in which occur three or four layers of radially placed triradiates, among which are interspersed numerous gastral quadriradiates. All these spicules are oriented in the usual way, with their paired rays pointing towards, and their basal ray away from, the osculum.

The skeleton of the flagellated chambers, or tubar skeleton, is articulate, and consists of six or eight joints, or less, according as the chamber has or has not attained its full growth. The proximal joint is composed of spicules slightly different in appearance and size from those of the other joints, being provided with a large basal ray and somewhat shorter paired rays. At the distal ends of the tubes the triradiates are supplemented by considerable numbers of oxea, which form a widely divergent crown to the chamber and project some way from the surface. A few of the subgastral triradiates possess apical rays, thus becoming quadriradiates; this apical ray never projects into the gastral cavity but lies like the paired rays, in the gastral cortex.

In the upper part of the stalk the main mass of the skeleton is composed of triradiates, which lie in many layers quite filling up the thick wall. These spicules are very markedly sagittal, being provided with an extremely long basal ray directed towards the base of the stalk, and two comparatively short oral rays which encircle the stalk. This part of the sponge does not seem to be provided with quadriradiates, as none of these could be found in any of the specimens examined, nor do apical rays project into the stalk-cavity. Between these triradiates, however, there lie large numbers of oxea of two kinds, the first large and very long, the others delicate and hair-like. The large oxea lie more or less parallel to the basal ray of the triradiates, but project considerably from the surface. Their ends point more or less towards the base of the stalk. The smaller oxea

are arranged radially, with their free ends projecting from the sponge-surface, and they occur in enormous numbers.

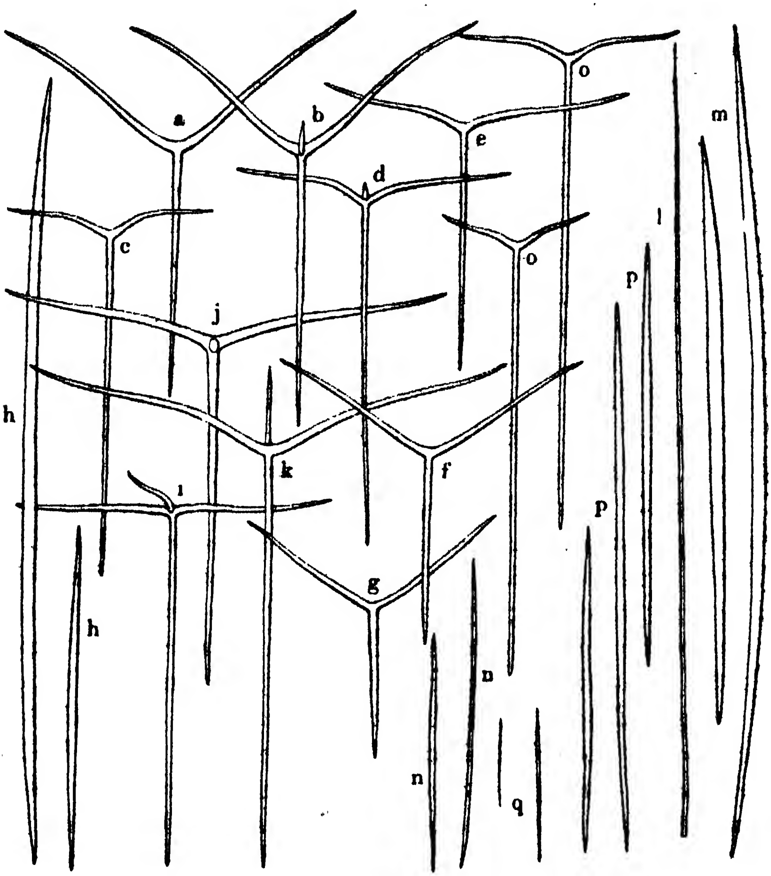
Spicules (Text-fig. 8). — Triradiates of the gastral cortex (a) are regular, or subregular, with long, slender rays usually all of the same length, though sometimes the basal ray can be distinguished from the oral rays by its greater length as well as by its position. Nearly all the spicules are oriented in the usual way, with their basal rays pointing away from the osculum. The rays are all cylindrical in shape, and taper uniformly from base to apex. The average length of a ray of a fully grown spicule is 132 μ, and its diameter 6 μ.

Quadriradiates of the gastral cortex (b) nearly the same as the triradiates of the same except in the presence of an apical ray. Basal ray 160–190 μ long and 4–6 μ thick. Paired rays 100–140 μ long and about 4–6 μ thick. Apical ray 30–80 μ long and about 4 μ thick.

Subgastral tubar triradiates (c) sagittal in shape, and usually provided with a much elongated basal ray and short oral rays. The basal ray is slender, thicker at the base than at any other point of its length; it tapers slightly for a short distance from the base, then for the greater part of the rest of its length it is of the same diameter, while the actual apex is abruptly but sharply pointed. The paired rays are also slender, much shorter than the basal ray, and strongly curved so that the spicule is clearly alate in shape. They lie buried in the gastral cortex, between the tangential triradiates. The true oral angle is only rarely more than 120 degrees, but owing to the above mentioned curvature of the oral rays, which commences very close indeed to the base of the ray, the angle frequently appears to be very much larger. It is, however, to be noticed that these subgastral triradiates never become so decidedly alate as do the other spicules of the tubar skeleton. Basal ray 150–290 μ long by 4–6 μ thick; paired rays 53–80 μ long and 4-6 μ thick at the base.

Subgastral tubar quadriradiates (d) are exactly similar to the triradiates save for the presence of the apical ray, which is usually quite small, and scarcely ever exceeds 20 μ in length, or 4 μ in diameter.

Tubar triradiates of the distal joints (e) are somewhat stouter than the subgastral spicules, but their basal rays are longer than those of the former group. The basal ray is, as usual, straight, but the paired rays are so curved that they come to lie very nearly in the same



Text-fig. 8. *Sycon lendenfeldi*, n. sp.
a, Triradiate of the gastral cortex. b, Quadriradiate of the same. c, Subgastral tubar triradiate. d, Subgastral tubar quadriradiate. e, Tubar triradiate of the distal joint. f, Tubar triradiate of the most distal joint. g, Triradiate of the distal end of the chamber. h, Oxea at the distal end of the chamber. i, Quadriradiate of the oscular rim which forms the band nearest the osculum. j, Quadriradiate of the oscular rim composing the second row. k, Quadriradiate in the lower portion of the oscular membrane. l, Oxea of the inner oscular fringe. m, Oxea of the outer oscular fringe. n, Oxea of the corona. o, Triradiates of the stalk. p, Larger oxea of the stalk. q, Smaller oxea of the stalk. (All ×150)

straight line in most cases. The true oral angle of the spicule is about 150 degrees, and the bending of the paired rays occurs close

to the base. All the rays taper continuously, and more or less uniformly from the base to the apex, which is sharply pointed. Basal ray 150–170 μ long and 6–8 μ thick; paired rays 95–120 μ long and 6–8 μ thick.

Triradiates of the most distal joint of the tubar skeleton (f) are rather smaller than those of the other joints, and are approximately regular in shape, with comparatively short, stout rays. The rays taper evenly towards the apex, which is less sharply pointed than in the above spicules. Basal and paired rays are about 100 μ long; both about 6 μ thick at the base.

Triradiates of the distal end of the chamber (g). At the summit of the chamber occur a few triradiates with their basal rays forming part of the dermal spicule-tuft, and their paired rays placed astride of the end of the chamber. The true oral angle is similar in these spicules to that of the rest of the tubar triradiates, but the paired rays curve towards each other, following the outline of the end of the chamber, so that they have a quite different appearance to any of the other tubar triradiates. In an example of the spicule, the basal ray measured 130 μ in length and 6 μ in thickness, while the paired rays were 110 μ long by 6 μ thick.

Oxea at distal end of flagellate chamber (h) generally slightly curved, sharply pointed at both ends, 200–470 μ long and 6–10 μ thick.

Quadriradiates of the oscular rim which form the band nearest the osculum (i) possess a straight basal ray, directed away from the osculum, which is long, slender, and gradually and uniformly tapered from base to apex. Its actual point is extremely fine and sharp. The paired rays lie from their very commencement in the same straight line, so that the oral angle is 180 degrees. Seen at right angles to the facial plane, these rays appear straight, but in reality they are curved to follow the curvature of the oscular margin in which they lie. The apical ray is rather short; and still more slender than the other rays; its proximal part lies perpendicular to the facial plane and projects directly into the osculum, but about 20 μ from the base it becomes abruptly curved to point towards the osculum. It tapers gradually and uniformly from base to point. Basal ray 150–170 μ long and 5 μ thick; paired rays 70–90 μ long and 5 μ thick; apical ray 55–70 μ long and 3 μ thick.

Quadriradiates of the oscular rim composing the second row (j), that is the row immediately below the one above described, are somewhat different. The paired rays are considerably longer in comparison with the basal ray, all the rays are rather stouter, and the spicule is not so strikingly sagittal. The basal ray is straight, thickest at the base, and tapering thence gradually and more or less uniformly to the sharply pointed apex. Occasionally spicules can be found with their points blunt, but these are only a small minority. The paired rays usually enclose an oral angle not much, if any, greater than 120 degrees and usually they are sharply curved so that the spicule is decidedly alate in shape. The paired rays are slender, thickest at the base, and taper very gradually to the apex itself, which is usually somewhat blunt. The apical ray is usually short, (though they vary enormously in length in different spicules), comparatively stout, steeply curved throughout its length, so that, although it lies perpendicular to the facial plane at its origin, yet its distal portion points directly towards the osculum. It is conical in shape, tapering more or less uniformly from base to apex, which is sharply pointed. Basal ray 110–200 μ long and about 5 μ thick. Paired rays 110–120 μ long and 5 μ thick. Apical ray 10–25 μ long and 5 μ thick.

Quadriradiates in the lower portion of the oscular membrane (k), that is below the corona, are very similar in shape and size to those of the gastral cortex proper, the main differences being that the rays of the true gastral quadriradiates do not seem to reach quite so large a size as those of the oscular margin, which is especially the case with the basal ray, and that the apical rays of the gastral spicules are rather stouter. Basal ray 170–260 μ long and about 4–6 μ thick. Paired rays about 130 μ long and 4–6 μ thick. Apical ray about 70 μ long and 4 μ thick.

Oxea of the inner oscular fringe (l) are hair-like trichoxea, of great length in proportion to their width, and of approximately the same diameter throughout their length. The exact maximum length is extremely difficult to determine, owing to the fact that the great delicacy of the spicules renders them very liable to break. The average depth of the oscular fringe, however, is in most specimens about 1 mm., with a few spicules reaching 1.3 mm. in length. The actual diameter varies considerably, even in the same specimen, and

thick and thin spicule lie side by side. The average diameter varies in this way from 1-3 μ. The distal ends of these spicules are nearly always broken, but when present are seen to be sharply pointed, as are the inner ends.

Oxea of the outer oscular fringe (m) are of very different appearance, these being shorter, very much stouter, and spindle-shaped. They taper gradually from the centre to each end. Their average length is 350 μ, but specimens can be found as long as 500 μ. Their average diameter is 12 μ.

Oxea of the corona (n) are small trichoxea, not exceeding 250 μ in length or 2 μ in diameter. They are of the same diameter for the greater part of their length, only tapering away at their ends, which are sharply pointed.

Triradiates of the stalk (o) are very striking different from all the other triradiates that occur in this sponge, owing to their extreme sagittal form. The basal ray is much elongated, and the paired rays are considerably shorter than in the other spicules of this group. The basal ray is straight, of the same diameter for about two-thirds of its length, then gradually tapered to a point close up to the apex, whence the ray tapers abruptly to the point, which is blunt or even rounded. Sometimes there occurs a widening in the middle parts of the ray. The paired rays are short, the true oral angle between them is usually 120 degrees, but the rays bend outwards sharply about halfway through their length, so that they assume an alate appearance; in fact, the bending is frequently so pronounced that the rays come to lie in the same straight line. They are tapered gradually the whole distance from base to apex, but more rapidly near the apex than near the base. All the rays terminate in sharp points. Basal ray 250–270 μ, and paired rays 30-70 μ long; both 4–5 μ thick.

Larger oxea of the stalk (p) are spindle-shaped, extremely variable in length, which varies from 190 μ to 750 μ, and about 4–6 μ in diameter, though this is also variable. They taper from the centre evenly toward each end.

Smaller oxea of the stalk (q) are extremely slender hair-like trichoxea, not averaging more than 100 μ in length, or 2 μ in thickness.

Embryology. — In two of the specimens of this species that were microscopically examined after staining, embryos were found in large

numbers in the cavities of the flagellate chambers. As far as could be ascertained these embryos are typical amphiblastulae, and though full details of their structure could not be made out, owing to the method of preservation employed, yet enough was seen to render it certain that if there are differences between the embryos of this species and the typical amphiblastula, they are so slight as to be quite unimportant.

The presence of these embryos is of great interest from the point of view of the canal system. It has been previously pointed out that the presence of collared cells in the gastral cavity is of no importance in an immature specimen, and the discovery of embryos, both by VON LENDENFELD in *Sycon sycandra,* and in this species, is of great importance as showing that the sponge is fully adult.

Localities and Register Nos. of Specimens.—Fremantle District (Station 36), AP, AQ_5; (Station 37), AS_2 I, AS_2 II, AS_3. Albany District (Station 61), A_7; (Station 64), A_2.

22. Sycon minutum DENDY

(Pl. XX, Fig. 10)

Sycon minutum, DENDY, 1892, p. 80; DENDY and ROW, 1913, p, 747.

This species is represented in the collection by two specimens.

The first specimen (No. A_{13}; Pl. XX, Fig. 10) forms a small colony of four *Sycon* individuals, each of which was attached to a sea-plant. The largest individual measures about 6 mm. in total length by about 2 mm. in diameter. Its terminal osculum is provided with an oscular fringe about 0.5 mm. high. It has also a well-distinguished stalk for attachment.

The second specimen (No. AW_3) consists of numerous *Sycon* individuals, each of which was also attached to a sea-plant as in the case of the first specimen. The *Sycon* individuals are very variable in size, the larger measuring 8 mm. in length and 2.5 mm. in breadth while the smaller is only 1 mm. long and 1 mm. broad. The osculum is sometimes naked and sometimes provided with a fringe of spicules. Their form also varies greatly from an elongate cylinder supported by a short stalk to an oval sac without stalk.

In respect to the canal system, skeletal arrangement and spiculation, these two specimens are exactly identical with the type specimen.

Previously known Distribution. — Watson's Bay, Port Jackson (DENDY).

Localities and Register Nos. of Specimens. — Fremantle District (Station 45), A_{11}; Albany District (Station 63), AW_3.

23. Sycon raphanus O. SCHMIDT

Sycon raphanus, O. SCHMIDT, 1862, p. 14, Taf. 1, Figs. 2-2 d; 1864, p. 32; POLÉJAEFF, 1883, p. 40; TOPSENT, 1894 (1), p. 37; DENDY, 1893, p. 80; BREITFUSS, 1896, p. 428; (3) 1898, p. 17; (4) 1898, p. 93; (5) 1898, p. 110; (6) 1898, p. 217; 1927, p. 29; LACKSCHEWITSCH, 1886, p. 302; ROW, 1909, p. 185; DENDY and ROW, 1913, p. 748.

Grantia raphanus, GRAY, 1867, p. 554.

Sycarium vesica, HAECKEL, 1870, p. 238.

Sycandra raphanus, HAECKEL, 1872, Bd. II, p. 312, Taf. 53, Fig. 4 a–t; Taf. 60, Fig. 7; F. E. SCHULZE, 1875, p. 247, Taf. XVIII-XXI; VON LENDENFELD, 1885, p. 1093; 1892, p. 246.

This very well known species is represented in the collection by two small individuals, apparently young. Each of them possesses the usual characteristics of the sponge, and the skeleton and spiculation are exactly like the type, when allowance is made for the smaller size, but it must be noted that with these young specimens, which very rarely present any very definite and distinctive characters, there is always a strong tendency to allocate them to known species on too slight grounds, especially when that species is not only common but also unmarked by any very distinctive characters. There is, however, a very strong argument in favour of this course; it is obviously better to assign the doubtful specimen to a species already known to occur in that region, and to whose characters it bears a more or less obvious resemblance, than to erect a new species on account of characters that may very possibly be due to immaturity. Thus, although no specimens of *Sycon raphanus* of large and characteristic size are present in this collection, we prefer to place these two individuals in that species on account of their very close general resemblance to it, rather than to leave them unidentified. To provide a new species on such slender grounds as lack of size would obviously be impossible.

Previously known Distribution. — Cosmopolitan: — White Sea; Murman Coast; Barents Sea; Greenland; Bergen; Coast of Portugal; Tristan da Cunha; Minorca; Gulf of Gabes; Mediterranean Sea;

Red Sea; Ceylon; Java; Gulf of St. Vincent; Port Phillip Heads; Bass Strait; King Island; Ternate; Phillippine Islands; Japan.

Localities and Register Nos. of Specimens. — Fremantle District (Station 36), AQδ; Albany District (Station 63), AW$_3\gamma$.

24. Sycon setosum O. SCHMIDT

Sycon setosum O. SCHMIDT, 1862, p. 15, Taf. 1; POLÉJAEFF, 1883, p. 24; DENDY, 1892, p. 81; DENDY and ROW, 1913, p. 748.

Grantia setosa, GRAY, 1867, p 554.

Sycum setosa, HAECKEL, 1870, p. 239.

Sycandra setosa, HAECKEL, 1872, Bd. II, p. 322; Bd. III, Taf. 53, Figs. 3 a–t; Taf. 60, Fig. 11; LENDENFELD, 1891, p. 73, Taf. XI, Fig. 60; Taf. XII, Figs. 85-92

Only a single specimen (Spec. No. A$_{11}$ from Station 14) in this collection could be assigned to this species.

It is oval in shape with a terminal osculum which is provided with a well-developed fringe and a corona. The sponge measures about 4 mm. long and 2.5 mm. broad across the middle part. The oscular fringe is about 2 mm. high.

In the general appearance, and in the skeleton arrangement and spiculation it corresponds very closely to the descriptions of this species made by the previous authors. The only difference exists in the comparatively shorter apical rays of the gastral quadriradiates.

Previously known Distribution. — Mediterranean Sea (O. SCHMIDT, HAECKEL, LENDENFELD); Near Port Phillip Heads (DENDY).

Locality and Register No. of Specimen. — Shark's Bay (Station 14), A$_{11}$.

25. Sycon verum, n. sp.
(Text-fig. 9)

In this collection the present species is represented by ten specimens of varying sizes. The largest specimen (Spec. No. AZ$_4\alpha$ from the Station 56) was taken as the type.

It is a pear-shaped sac with a narrowed base attached to seaweed. It measures 20 mm. in height and 9 mm. in diameter at the widest part, which is about 8 mm. below the summit. The greatest thickness of wall is about 2 mm. The osculum at the summit is oval with

greater diameter of 2.5 mm. It is provided with a feebly developed fringe of small oxea. The surface of the sponge is rather smooth shows an extremely regular pattern, caused by the alternation of the flagellate chambers and the inhalant canals, both of which are approximately square in cross-section and of subequal size. The gastral surface is uniformly perforated by numerous apertures of exhalant canals of up to 0.3 mm. diameter. The colour is greyish white and the texture is delicate.

Structures. — The gastral cavity is large but is narrowed toward the base. The flagellated chambers in the middle portion of the sponge body are long and comparatively wide. They occasionally branch near the gastral cavity. Those situated near the oscular rim and the sponge base are much smaller and are rather irregularly arranged. The position of the nucleus in collared cells is apical.

The tubar skeleton is composed of triradiates and quadriradiates arranged in numerous joints, the first joint being formed by the basal rays of subgastral triradiates. The apical rays of the quadriradiates, which project into the cavity of the flagellate chamber, are directed slightly towards the exhalant aperture of the latter. At the distal ends of the flagellate chambers are set a considerable number of small oxea projecting some way from the surface.

The gastral skeleton is made up of triradiates, quadriradiates and the paired rays of subgastral triradiates. The former two kinds of spicules are rather thickly distributed around the gastral apertures, their basal rays being directed downwards and their apical rays projecting into the gastral cavity.

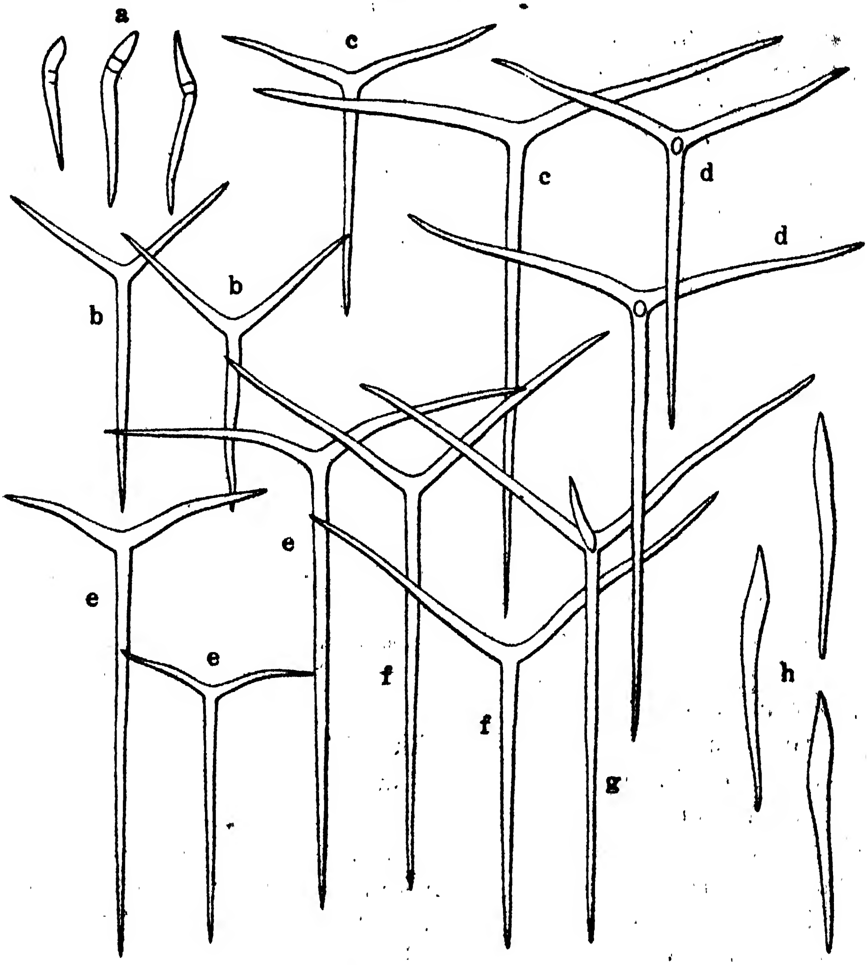
The oscular margin is rather thick being composed chiefly of small oxea equally distributed on both the inner and the outer surfaces.

Spicules (Text-fig. 9). — Oxea at the distal ends of flagellate chambers (a) short, more or less club-shaped, usually with the thicker distal portion bent marking an angle with the narrowed proximal portion. At the distal portion a fully developed ring-like thickening is noticeable. They are about 70 μ long and about 8 μ thick at the distal portion.

Tubar triradiates of the most distal joint (b) are rather smaller than those of the other joints. They are nearly regular or slightly sagittal with rays gradually and sharply pointed. Basal ray straight,

about 80 μ long and 6–8 μ thick at the base. Paired rays curved following the curvature of the outer surface of the flagellate chamber. They are about 70 μ long and 6-8 μ thick at the base.

Tubar triradiates (c) sagittal. Basal ray straight, longer and slightly thinner than the paired rays, tapering from base to sharp point, 100–



Text-fig 9. *Sycon verum*, n. sp.
a, Oxea at the distal end of flagellate chamber. b, Tubar triradiates of the most distal joint. c, Tubar triradiates. d, Tubar quadriradiates. e, Subgastral triradiates. f, Gastral triradiates. g, Gastral quadriradiate. h, Oxea of oscular rim. (All ×300)

180 μ long and 6–8 μ thick at the base. Paired rays widely divergent, either simply curved forwards or doubly curved first backwards and then forwards, ending in sharp points, 60–110 μ long and 8–10 μ thick at the base.

Tubar quadriradiates (d) exactly similar to the tubar triradiates with the addition of a short apical ray. Apical ray slightly curved and sharply pointed, 30–40 μ long and about 8 μ thick at the base.

Subgastral triradiates (e) sagittal. All rays are regular in contour and nearly equally thick. Basal ray longer than paired rays, quite straight, gradually tapering to a sharp point, 70–180 μ long and 6–8 μ thick at the base. Paired rays strongly divergent, curved rather angularly in the middle parts, 40–90 μ long and 6–8 μ thick at the base.

Gastral triradiates (f) sagittal. Basal ray slightly longer than paired rays, quite straight, tapering from base to the sharp point, 70–160 μ long and 6–8 μ thick at the base. Paired rays nearly equal in length, slightly curved forwards, 60–120 μ long and 6–8 μ thick at the base.

Gastral quadriradiates (g) exactly similar to the gastral triradiates save for the presence of an apical ray. Apical ray short but stout, straight and uniformly thick for about $\frac{2}{3}$ of its length, then bending slightly upwards and tapering more suddenly to a sharp point, 40–60 μ long and about 6–8 μ thick at the base.

Oxea of oscular rim (h) are nearly similar to those found at the distal cones, but not strongly curved and more elongated, about 90 μ long and 8 μ thick.

Localities and Register Nos. of Specimens. — Geraldton District (Station 31), AF_1, AH_2, AH_3; Bunbury Bay (Station 56), $A_5\alpha$, $A_5\beta$, $A_5\gamma$, AX_1, $AZ_4\alpha$, $AZ_4\beta$, $AZ_4\gamma$.

Family **Heteropiidae** Dendy

Genus GRANTESSA von Lendenfeld

26. **Grantessa hirsuta** (Carter)

Hypograntia hirsuta, Carter, 1886, p. 41.
Grantessa hirsuta, Dendy, 1892, p. 106; Dendy, and Row, 1913, p. 752

This species is represented by eight specimens in the collection.

They are either oval or elongate sac-shaped in form, provided with a terminal osculum. The largest specimen (Spec. No. BL from Station 64) measures 8 mm. wide in the broadest part and about 15 mm. long excluding the oscular fringe about 3 mm. high. The sponge surface is strongly hispid from the projecting oxea. The smallest specimen (Spec. No. AZ_1 from Station 56) measures about 6 mm. in length and 4 mm. in greatest breadth.

The specimen (Spec. No. BM from Station 64) has a surface which seems comparatively smooth, being deprived of strongly echinating oxea, and also has the osculum almost naked. But it is quite obvious that the above features were artificially produced during the treatment of the specimen.

Previously known Distribution. — Near Port Phillip Heads (CARTER, DENDY); King Island; Hobart, Tasmania (DENDY).

Localities and Register Nos. of Specimens. — Bunbury Bay (Station 56), AZ_2; Albany District (Station 64), BK_1, BK_2, BL, BM, BN_1, BN_2, BO.

27. **Grantessa polyperistomia** (CARTER)

Heteropia polyperistomia, CARTER, 1886, p. 47.
Grantessa (?) polyperistomia, DENDY, 1892, p. 109.
Grantessa polyperistomia, DENDY and ROW, 1913, p. 753.

The collection contains three specimens of this species.

The first specimens (Spec. No. AK_1 from Station 32) is a small colony of irregularly anastomosing tubes, the individuality of which is indicated only by the number of oscula. There are seven oscula of which some are surrounded by a feebly developed fringe of oxea while the others are naked. The whole colony measures 15 mm. in length, about 6 mm. in greatest breadth and 0.6 mm. in thickness of wall. The dermal surface appears more or less rough from the projecting large oxea. The gastral surface is smooth without any projecting spicules.

The remaining two specimens (Spec. No. $AJ_3\beta$ from Station 31 and Spec. No. BE from Station 56) are much smaller than the first but are of nearly equal appearance.

In the anatomical structures these three specimens represent nearly the same features as shown in the descriptions made by CARTER.

The canal system is syconoid, though not in a very typical way. The flagellate chambers which are radially arranged around the gastral cavity are rather short, and are not quite straight, being more or less crooked. They usually branch once or twice.

Previously known Distribution.—Near Port Phillip Heads (CARTER).

Localities and Register Nos. of Specimens.—Geraldton District (Station 31 and 32), AK_1, $AJ_8\beta$; Bunbury Bay (Station 56), BE.

28. Grantessa sacca LENDENFELD

Grantessa sacca, LENDENFELD, 1885, p. 1098, Figs. 41, 42; DENDY, 1891, p. 106; DENDY and ROW, 1913, p. 753.

Hypograntia sacca, CARTER, 1886, p. 42.

There exists a single specimen of the species in the collection (Spec. No. BH_1 from Station 64). It is a solitary person of an irregularly bent tubular shape. The osculum at the upper end is surrounded by a well-developed fringe of oxea. Total length of body about 30 mm., greatest breadth about 4 mm., and the wall less than 1 mm. thick. The circular osculum measures about 3 mm. in diameter.

The canal system is of the syconoid type and the flagellate chambers, as DENDY pointed out, branch repeatedly, each branch running usually parallel with the others.

Previously known Distribution.—Port Jackson (LENDENFELD); Near Port Phillip Heads (CARTER, DENDY).

Locality and Register Nos. of Specimen.—Albany District, S. W. Australia (Station 64), BH_1.

26. Grantessa intusarticulata (CARTER)

Hypograntia intusarticulata, CARTER, 1886, p. 45.

Hypograntia medioarticulata, CARTER, 1886, p. 46.

Grantessa intusarticulata, DENDY, 1892, p. 108; 1893, pp. 181, 201, Pl. XIII, Fig. 18; DENDY and ROW, 1913, p. 753; HÔZAWA, 1916, p. 14, Pl. I, figs. 4, 5; Pl. II, fig. 13 Text-fig. 3; 1929, p. 318; BRØNDSTED, 1926, p. 308.

Grantia intusarticulata, BREITFUSS, 1897, p. 219.

There are three specimens of this species in the collection. They were all collected at Station 31, and are solitary tubular individuals.

The first specimen (Spec. No. AH_4) is a fragment of an oscular tube without the basal part. It measures about 8 mm. in length and

4 mm. in greatest breadth. The osculum at the terminal end is nearly circular, measuring 1.5 mm. across. It is surrounded by a feebly developed fringe of oxea.

The second specimen (Spec. No. $Z_2\alpha$) is also fragment of an oscular tube, the basal portion of which is torn off. It is 7 mm. long and 3.5 mm. broad in the broadest part. The osculum is nearly naked and circular in outline with a diameter of 1 mm.

The third specimen (Spec. No. $Z_2\beta$) represents an irregularly cylindrical person which has budded out three much smaller persons near the middle region.

The mother person measures about 17 mm. in length by 2.5 mm. broad at the widest part. The terminal osculum is circular with a diameter of about 1 mm. and is provided with a fringe of oxea about 0.5 mm. high.

The species has been fully recorded by previous authors, so that no further details are necessary to be added here.

Previously known Distribution. — Near Port Phillip Heads (CARTER, DENDY); Watson's Bay, Port Jackson (DENDY); Sagami Sea, Japan (HÔZAWA); Island Bay, Wellington, N. Z. (BRØNDSTED).

Localities and Register Nos. of Specimens. — Geraldton District, S. W. Australia (Station 31), AH_4, $Z_2\alpha$, $Z_2\beta$.

Genus HETEROPIA CARTER (emend.)

30. Heteropia glomerosa (BOWERBANK)

Leuconia glomerosa, BOWERBANK, 1873, p. 17, Pl. IV, Figs. 1–6.
Heteropia glomerosa, DENDY and ROW, 1913, p. 754; DENDY, 1915, p. 83, Pl. I, Figs. 3, 3 a, 3 b; Pl. II, Figs. 8 a–8 g.
Heteropia simplex, ROW, 1913, p. 754.

There exist seven specimens of this species in the collection.

This species was first described by BOWERBANK in 1873 and afterwards fully recorded by DENDY in 1915.

The specimens in the collection are of much smaller size than those described by DENDY and the mode of branching of the individual tube is more simple than in the latter. But in anatomical structure they show no difference.

Previously known Distribution. — Port Elizabeth, South Africa

(BOWERBANK); Near Okhamandal Point; S. W. Coast of Beyt Island, India (DENDY).

Localities and Register Nos. of Specimens. — Shark's Bay District, S. W. Australia: (Station 1) A_6; (Station 14), A_{16}; (Station 15), L, S_2III; (Station 16), A_8II, P; Bunbury Bay (Station 56), A_{10}.

Genus VOSMAEROPSIS DENDY

31. **Vosmaeropsis dendyi,** n. sp.

(Pl. XX, Fig. 11; Text-fig. 10)

This new species is represented in the collection by two specimens of closely similar appearance. To base further description on, I have selected one of the above specimens labelled AQ_6a (Pl. XX, Fig. 11).

The sponge is a solitary person of an irregularly bent and slightly laterally compressed tubular shape. It measures about 10 mm. in total length and 2 mm. in greatest breadth, the wall reaching about 1 mm. in thickness. The osculum at the upper end is surrounded by a well-developed fringe of oxea about 1 mm. high. The dermal surface is fairly hispid, due to projecting oxea. The gastral surface is also more or less rough on account of the projecting apical rays of the gastral quadriradiates and is perforated by irregularly distributed circular or oval exhalant apertures, up to 0.3 mm. wide.

The colour in alcohol is greyish white and the texture is moderately firm.

Structure. — The canal system is of the leuconoid type. The chamber layer is strongly lacunar owing to the wide inhalant and exhalant canals. Between the inhalant and exhalant canal systems the flagellate chambers are fairly thickly distributed. They are ovoid or spherical with a diameter of 50–100 μ.

The dermal skeleton is composed chiefly of triradiates which are placed tangentially with the basal ray pointing downwards. In addition to these spicules there occur in the skeleton a few tangential quadriradiates and paired rays of subdermal pseudosagittal triradiates. The quadriradiates are placed tangentially with the basal ray directed downwards and the apical ray imbedded in the chamber layer. A number of large oxea and trichoxea placed perpendicularly or somewhat obliquely to the dermal surface, project to some extent beyond

the surface, their proximal parts being imbedded in the chamber layer. Microxea are thinly distributed on the dermal surface.

The skeleton of the chamber layer is composed of apical rays of dermal quadriradiates, basal rays of subdermal pseudosagittal triradiates, triradiates in two or three irregular layers and the basal rays of subgastral quadriradiates.

The gastral skeleton is made up of a thin layer containing the paired rays of subgastral quadriradiates as well as of gastral quadriradiates. The basal rays of the gastral quadriradiates point downwards in most cases, while the apical rays project into the gastral cavity.

The skeleton of the oscular margin is composed of trichoxea, triradiates and quadriradiates, all placed densely together. The trichoxea run longitudinally and parallel with one another. The tri- and quadriradiates have their basal rays directed regularly downwards.

Spicules (Text-fig. 10). — Dermal triradiates (a) slightly sagittal. All rays nearly equally thick and gradually sharp pointed. Basal ray straight, usually longer than paired rays, 160–300 μ long und 12–16 μ thick at the base. Paired rays slightly curved forwards, 140–200 μ long and 12–16 μ thick at the base.

Dermal quadriradiates (b) exactly similar to dermal triradiates, differing only in the presence of an apical ray. Apical ray nearly straight, standing at right angles with facial rays, about 120 μ long and 12 μ thick at the base.

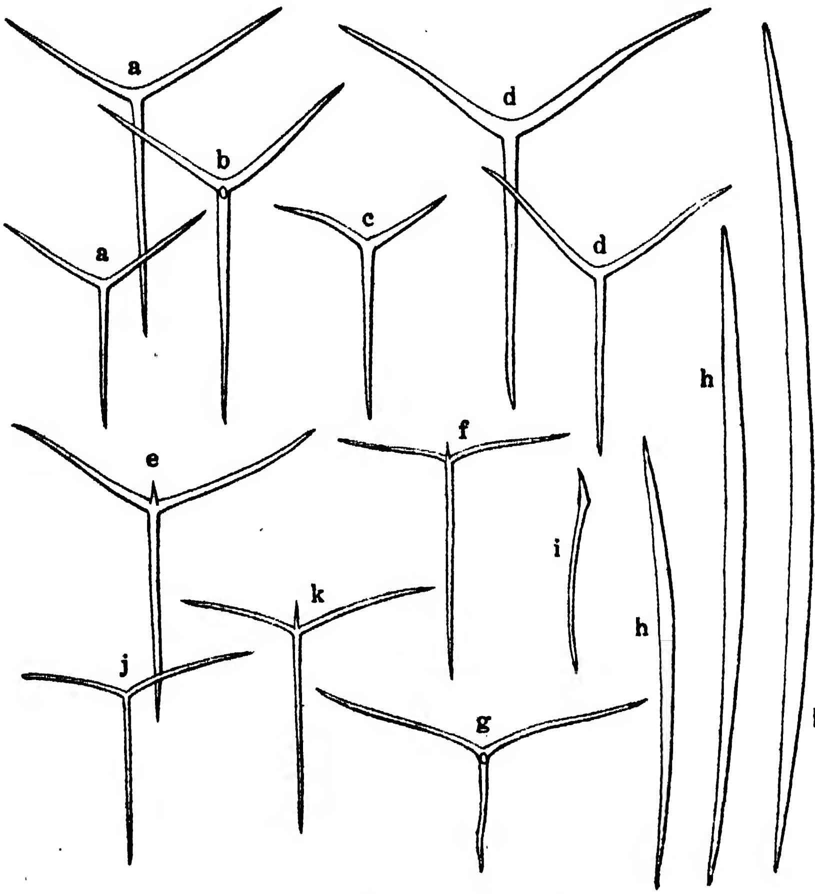
Subdermal triradiates (c) pseudosagittal. All rays nearly equally thick, gradually tapering to a sharp point. Basal ray longer than the paired rays, nearly straight, about 200 μ long and 16 μ thick at the base. The longer of the paired rays slightly bent in the middle part, 140 μ long and 16 μ thick at the base. The shorter of the paired rays nearly straight, 120 μ long and 16 μ thick at the base.

Triradiates of chamber layer (d) sagittal. All rays nearly equally thick, often irregular in outline. Basal ray straight, usually slightly longer than paired rays, 200–300 μ long and 16–24 μ thick at the base. Paired rays in most cases recurved, first forwards and then slightly backwards, 200–280 μ long and 16–24 μ thick at the base.

Quadriradiates of the larger exhalant canals (e) sagittal, nearly like the triradiates of the chamber layer, but with an apical ray. Apical ray much shorter and thinner than facial rays, slightly curved

and sharply pointed. In an example of the spicule, basal ray 260 μ long, paired rays both 200 μ long by 14 μ thick; apical ray 50 μ long and 8 μ thick.

Subgastral quadriradiates (f) sagittal, with sharply pointed facial rays of nearly equal thickness. Basal ray longer than paired rays, nearly straight, about 260 μ long and 10 μ thick at the base. Paired



Text-fig. 10. *Vosmaeropsis dendyi*, n. sp.
a, Dermal triradiates. b, Dermal quadriradiate. c, Subdermal triradiate. d, Triradiates of chamber layer. e, Quadriradiate of larger exhalant canal. f, Subgastral quadriradiate. g, Gastral quadriradiate. h, Oxea projecting from dermal surface. i, Microxea of dermal cortex. j. Triradiate of oscular margin. k, Quadriradiate of oscular margin. (a–h, j, k ×100; i ×300)

rays strongly diverging and usually recurved first backwards and then forwards, about 140 μ long and 10 μ thick at the base. Apical ray much shorter and slightly thinner than facial rays, measuring about 50 μ long and 6 μ thick at the base. It stands at right angles from the centre of the facial rays.

Subgastral triradiates almost similar to the quadriradiates of the same, differing only in the absence of the apical ray.

Gastral quadriradiates (g) sagittal. Basal ray usually shorter than paired rays and more or less irregularly curved, about 120 μ long and 10 μ thick at the base. Paired rays widely diverging, nearly uniformly thick and gently curved backwards in the greater part of their length and either straight or slightly curved forwards in the terminal parts, gradually tapering to sharp point, about 180 μ long and 10 μ thick at the base. Apical ray shorter than both basal and paired rays, measuring up to 100 μ in length. It is slightly curved upwards and finely pointed.

Oxea projecting from dermal surface (h) usually slightly curved, nearly uniformly thick in the greater part of their length though tapering at the ends which are fairly sharply pointed, 0.6–1.2 mm. long and 24–32 μ thick at the thickest part.

Trichoxea projecting from dermal surface straight or slightly curved, generally with the free end broken off and sharply pointed at the inner end. An example of the spicule measured 260 μ long and 3 μ thick.

Microxea of dermal cortex (i) slightly curved, tapering proximally to a sharp point, distally terminating with a lance-head which is distinguished from the body by its nob-shaped neck. An example of the spicule measured 160 μ long and 3 μ thick.

Triradiates of oscular margin (j) sagittal. Basal ray usually longer and more slender than the paired rays, sharply pointed at the end, about 140 μ long and 6 μ thick at the base. Paired rays strongly diverging, slightly and gently curved backwards, equally thick for the greater part of their length and rather bluntly pointed at the end, about 130 μ long and 8 μ thick at the base.

Quadriradiates of oscular margin (k) exactly similar to triradiates of the same, but with an apical ray which is shorter and thinner than the facial rays. In an example of the spicule, the basal ray is 260 μ

long and 6 μ thick, and the paired rays 160 μ long and 8 μ thick at the base.

Trichoxea of oscular margin straight or slightly curved, uniformly thick throughout the entire length excepting the sharply pointed ends. They are variable in length and thickness. A small example of the spicule measured 500 μ long and 2 μ thick, while a large one measured over 1 mm. long by 4 μ thick.

Locality and Register Nos. of Specimens.—Fremantle District, S. W. Australia (Station 36), $AQ_6\alpha$, $AQ_6\beta$.

Family **Grantiidae** Dendy

Genus GRANTIA Fleming (emend.)

32. **Grantia genuina**, n. sp.

(Pl. XX, Fig. 12; Text-fig. 11)

Only a single specimen of this new species exists in the collection (Pl. XX, Fig. 12). It is of an elongate ovoid shape, measuring 7 mm. in length and about 2 mm. in greatest breadth. The thickness of wall measures about 1 mm. in the middle parts of the body. The outer surface of the sponge is hispid, owing to the presence of oxea projecting from it. The osculum at the upper end is circular and is provided with a fringe about 0.8 mm. high.

Structure.—The canal system is of the typical syconoid type. The flagellate chambers are cylindrical, nearly equally wide in the greater parts, unbranched or very slightly branched. They attain about 1 mm. in length and 0.15 mm. in diameter. The dermal skeleton consists of a few layers of triradiates which are tangentially, but otherwise rather irregularly, placed. Among these spicules occur quadriradiates in sparce distribution with their basal rays pointing downwards and with apical rays protruding into the sponge wall. Large oxea project perpendicularly or somewhat obliquely from the dermal surface, their proximal parts being deeply inbedded in the sponge wall.

The tubar skeleton is of the 2 or 3-jointed articulated type and is made up of triradiates. There may be added the basal rays of subgastral triradiates.

The gastral skeleton forms a thin layer consisting of the paired rays of subgastral triradiates and of quadriradiates with the basal ray

generally pointing towards the base of the sponge and the apical ray projecting into the gastral cavity in oblique inclination towards the osculum. The skeleton of oscular margin is composed of oxea and quadriradiates. The oxea are arranged longitudinally and the basal rays of the quadriradiates are directed downwards.

Spicules (Text-fig. 11).—Dermal triradiates (a) strongly sagittal. Basal ray straight, sharply pointed, distinctly shorter and a little thicker than paired rays, 30–60 μ long and 6–8 μ thick at the base. Paired rays slightly curved, standing nearly at right angles to basal ray, 120–170 μ long and 4–6 μ thick at the base.

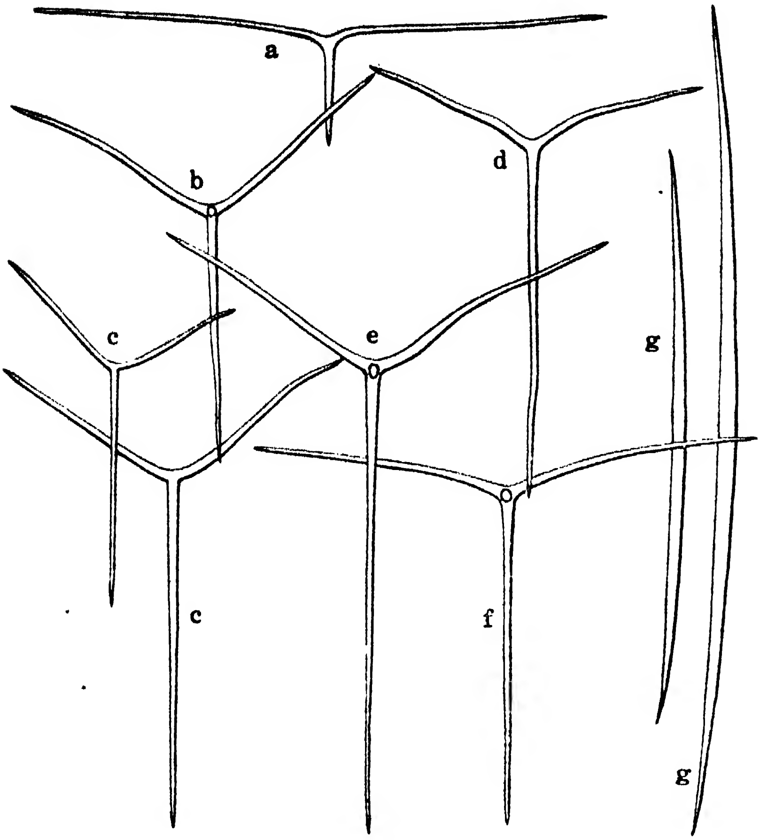
Dermal quadriradiates (b) sagittal. Basal ray straight, sharply pointed, longer than paired rays, about 170 μ long by 8 μ thick. Paired rays a little shorter than basal ray, curving first forwards and then backwards, about 130 μ long and 8 μ thick at the base. Apical ray straight in the basal parts and slightly curved in the distal parts ending in a very finely pointed end, about 120 μ long by 8 μ thick.

Tubar triradiates (c) sagittal, more or less varying in size and shape. Basal ray straight, gradually sharp-pointed, much longer and slightly thicker than paired rays, 150–200 μ long and 8–10 μ thick at the base. Paired rays slightly curved forwards in basal parts and nearly straight or weakly curved backwards in the remaining parts, 70–100 μ long and 6–8 μ thick at the base.

Subgastral triradiates (d) sagittal. Basal ray nearly straight, longer and thicker than paired rays. Paired rays very widely extended, curved at a point nearer the base than the sharply pointed end. In a typical example of the spicule the basal ray measured 200 μ by 10 μ and the paired rays about 150 μ long by 8 μ thick.

Gastral quadriradiates (e) sagittal. Rays nearly equally thick, gradually tapering to a sharp point. Basal ray straight, longer than paired rays. Paired rays slightly doubly curved, first forwards then backwards. Apical ray much shorter than facial rays, slightly curved upwards, ending in a sharp point. In a typical case the basal ray measures about 300 μ by 10 μ; the paired rays about 150 μ by 8 μ, and the apical ray about 70 μ by 6 μ.

Quadriradiates of the oscular collar (f) very strongly sagittal. Basal ray straight, longer than paired rays, gradually and finely pointed. Paired rays very widely diverging and curved backwards, gradually



Text-fig. 11. *Grantia genuina*, n. sp.
a, Dermal triradiate. b, Dermal quadriradiate. c, Tubar triradiates. d, Subgastral triradiate. e, Gastral quadriradiate. f, Quadriradiate of oscular collar. g, Large oxea projecting from the dermal surface. (All ×200)

and sharply pointed. Apical ray very short. In an example of the medium sized spicule, the basal ray measured 200 μ long by 6 μ thick and the paired rays 160 μ long by 6 μ thick.

Large oxea (g) nearly straight or slightly curved, either fusiform or nearly uniformly thick throughout the greater length and sharply pointed at both ends, about 500–900 μ long and 8–15 μ thick.

Remarks. — The present species gives the second example in the presence of apical rays in the tangential dermal radiates and thus reminds us of the starting point for the family Amphoriscidae. The

first example of this case is seen in *Grantia intermedia* THACKER[1].

Locality and Register No. of Specimens. — Shark's Bay District (Station 3) AI.

Genus GRANTIOPSIS DENDY (emend.)

33. Grantiopsis cylindrica DENDY

Grantia (Grantiopsis) cylindrica. DENDY, 1892, pp. 90–92; 1893, pp 173, 194, 232, figs. 11, 52–57.

Grantiopsis cylindrica, DENDY and ROW, 1913, p. 763; DENDY and FREDERICK, 1924, p. 485, Pl. 25, figs. 5, 6, 7, 8; Pl. 26, fig. 7.

This interesting species is represented by a single specimen in the collection. It is in the form of a cylindrical tube which is slightly curved and provided with a single terminal osculum of about 1 mm. diameter. The total length is about 13 mm. and the greatest breadth is about 4 mm.

Previously known Distribution.—Near Port Phillip Heads (DENDY); Abrolhos Islands, Western Australia (DENDY and FREDERICK).

Locality and Register No. of Specimen. — Geraldton District (Station 31), AH_3.

Genus SYNUTE DENDY

34. Synute pulchella DENDY

Synute pulchella, DENDY, 1892, pp. 1–6; DENDY, 1892, p. 96; DENDY and ROW. 1913, p. 764.

Grantia (Synute) pulchella, DENDY, 1893, pp. 176–177, 196–197, 233–234.

In this collection exist two specimens of this remarkable species. They are quite different in external appearance but are entirely the same in internal structure.

Smaller specimen is cylindrical in form and is irregularly curved. It is narrow near the attachment base and becomes broader towards the upper rounded end where the oscula are located. The oscula are six in number and are of variable sizes measuring 0.25–0.6 mm. in diameter. The specimen attains a length of about 28 mm. and a maximum diameter of about 5 mm.

[1] *Grantia intermedia*, THACKER, 1908, pp. 770–771.

The larger specimen is irregular fan-shaped in form being narrow at the base and broadening towards the upper end. The surface is not even, being provided with many ridges of variable breadth and height which arise at the upper end and converge towards the base. The upper end forms a maeandering ridge and is provided with a number of small oscula in a rather irregular arrangement. Each of the oscula is circular with a diameter less than 1 mm. and is not surrounded by an oscular fringe but is raised on an indistinct papilla. The specimen is about 38 mm. in greatest breadth, 30 mm. in length and 3–8 mm. in thickness.

We have nothing to add to the description of this remarkable sponge which was fully given by DENDY.

Previously known Distribution. — Near Port Phillip Heads (DENDY).

Locality and Register Nos. of Specimens. — Bunbury Bay (Station 56), BA and BF.

Genus LEUCANDRA HAECKEL (emend.)

35. Leucandra meandrina VON LENDENFELD

Leucandra meandrina, VON LENDENFELD, 1885, pp. 1128–1129, Pl. 67, figs. 43, 44; DENDY and ROW, 1913, p. 771.

The collection contains a single specimen of this species. The sponge is in the form of a rather thick-walled and slightly curved cylindrical tube about 40 mm. long, broadest in the middle parts and becoming narrower towards the base and the upper end. Maximum breadth of body is about 15 mm.

The terminal osculum is 3 mm. in maximum diameter and is surrounded by a feebly developed fringe. The sponge wall is about 3 mm. thick at the broadest part of the body.

Previously known Distribution. — East coast of Australia, Port Jackson (VON LENDENFELD).

Locality and Register No. of Specimen. — Fremantle District (Station 37), AR.

36. Leucandra minima, n. sp.

(Pl. XXI, Fig. 13; Text-fig. 12)

This new species is found on the strength of a single specimen in

the collection (Pl. XXI, Fig. 13). The sponge is in the form of a rather short cylindrical tube, broadest at about the middle and gradually narrowed towards the attachment base and upper osculum. The total length of body is about 8 mm. and the greatest breadth is about 3 mm. The osculum measures less than 1 mm. in diameter and is not surrounded by a conspicuous fringe. The wall of the tube is about 1 mm. in thickness. The gastral cavity is of a habitus corresponding to that of the entire specimen and is comparatively narrow, measuring about 1 mm. in greatest diameter. The dermal surface is slightly hispid, due to the projecting oxea. The gastral surface appears more or less rough from the apical rays of the gastral quadriradiates.

Structure. — The canal system is of the leuconoid type. The flagellate chambers are of a sac-like shape, circular or oval in cross-section with a diameter of 50–100 μ. The apertures by which the exhalant canals open into the gastral cavity measure up to 150 μ across.

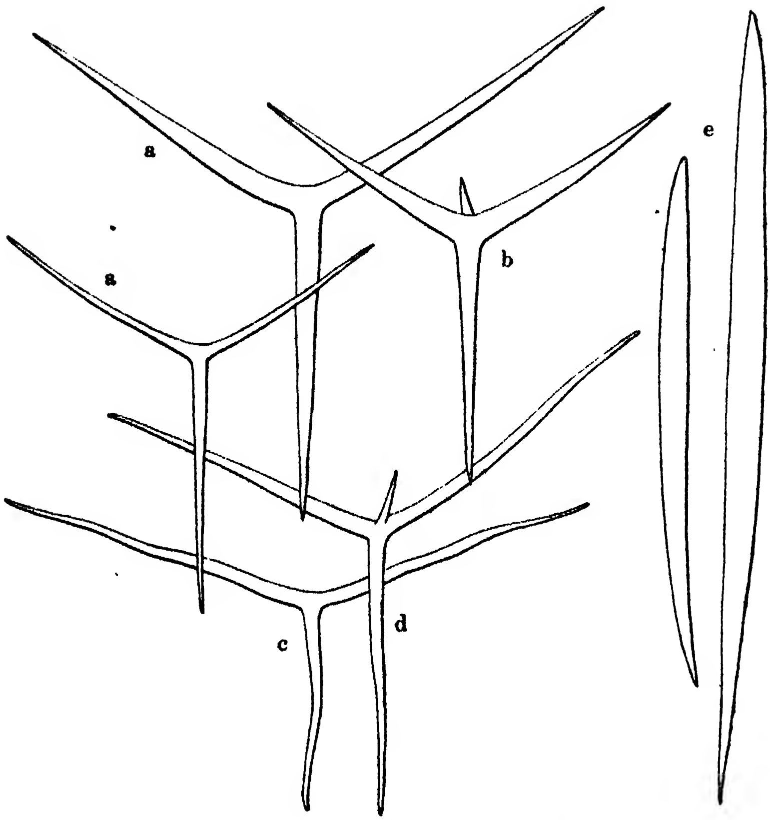
The dermal skeleton is composed of triradiates, trichoxea and large oxea. The triradiates are placed tangentially in a few layers, with their basal rays pointing more or less downwards. The trichoxea are rather scarce and lie at varying angles to the dermal surface. They have the tendency to be grouped into small tufts. The long oxea, which occur here and there in nearly vertical disposition in the sponge wall, project outwards on the dermal side to some extent.

The tubar skeleton is made up of triradiates and quadriradiates of various sizes. They are irregularly scattered through the chamber layer.

The gastral skeleton is thin, consisting of triradiates and quadriradiates both fairly closely set and disposed parallel to the gastral surface in a few layers but without definite orientation.

Spicules (Text-fig. 12). — Dermal triradiates (a) slightly sagittal with rays of nearly equal length and thickness and tapering from base to sharp point. Basal ray straight, measuring 220–280 μ in length and 14–28 μ in thickness at the base. Paired rays either gently curved forwards or irregularly curved, 170–300 μ long and 14–28 μ thick at the base.

Triradiates of the chamber layer are almost like the dermal triradiates.



Text-fig. 12. *Leucandra minima*, n. sp.
a, Dermal triradiates. b, Quadriradiate of the chamber layer. c, Gastral triradiate. d, Gastral quadriradiate. e, Dermal oxea. (All ×150)

Quadriradiates of chamber layer (b) similar to the triradiates of the same, except in the presence of an apical ray. Apical ray much shorter and slightly thinner than the facial rays, slightly curved and gradually tapering to a sharp point, 60–100 μ long and 14–20 μ thick at the base.

Gastral triradiates (c) sagittal, rather slender-rayed. All rays are nearly equally thick and are more or less irregular in outline. Basal ray irregularly curved and is in most cases shorter than paired rays, about 200 μ long and 8 μ thick at the base. Paired rays widely diverging and slightly curved forwards at the base, about 280 μ long

and 8 μ thick at the base.

Gastral quadriradiates (d) almost like gastral triradiates with the addition of an apical ray. Apical ray much shorter and thinner than the facial rays, slightly curved and ending sharply, 100–200 μ long and 10–16 μ thick at the base.

Dermal oxea (e) cylindrical, usually slightly curved, rather irregular in outline, sharply pointed at the outer end and more acutely pointed at the inner, 450-700 μ long and 20–40 μ thick in the middle.

Dermal trichoxea hair-like, straight, generally with the free end broken away, 2–3 μ thick.

Locality and Register No. of Specimen.—Shark's Bay District (Station 16), A_8I.

37. Leucandra pallida, n. sp.

(Pl. XXI, Fig. 14; Text-fig. 13)

A single specimen (Pl. XXI, Fig. 14) in the collection has served as the type of this new species.

The sponge is a solitary person of oval shape, being broad at the base and superiorly narrowed. Total length of body about 10 mm., greatest breadth about 7 mm., wall about 2 mm. thick in the thickest part. The osculum at the upper end is about 1.5 mm. in major diameter and is provided with a fringe of oxea about 1 mm. high. The dermal surface is slightly hispid due to the projecting oxea. The gastral surface is also more or less rough on account of the projecting apical rays of the gastral quadriradiates and of the projecting tufts of microxea.

The colour in alcohol is greyish white; the texture is delicate.

Structure.—The canal system is of the leuconoid type. The dermal skeleton is composed of the following elements: 1) triradiates which are tangentially arranged in a few layers with their basal rays mostly pointing downwards, 2) quadriradiates which are found among the triradiates above mentioned with their apical rays protruding into the chamber layer to some extent. 3) large oxea which occur in the sponge-wall projecting outwards on the dermal side, 4) microxea in sparce distribution standing nearly vertically to the dermal surface.

The skeleton of the chamber layer consists chiefly of triradiates of

variable sizes and of an irregular arrangement. Along the larger exhalant canals there occur some quadriradiates with their apical rays projecting into the canal.

The gastral skeleton is fairly well distinguishable from that of the chamber layer. It is composed of a thin layer of tangential quadriradiates with an apical ray projecting into the gastral cavity and of microxea which are grouped into tufts and occur here and there all over the gastral surface.

The skeleton of the oscular margin is a close interlacement of triradiates, quadriradiates and trichoxea. The tri- and quadriradiates have very strongly divergent paired rays and a downwardly directed basal ray. The oxea are arranged longitudinally.

Spicules (Text-fig. 13).—Dermal triradiates (a) slightly sagittal, with rays of nearly equal length and thickness. Basal ray straight and paired rays slightly curved forwards near the base. In an example of the spicule, the basal ray measures 200 μ by 20 μ and the paired rays measure 230 μ by 20 μ.

Dermal quadriradiates (b) exactly similar to the triradiates above mentioned, differing only in the presence of an apical ray. Apical ray straight, gradually and sharply pointed, standing vertically at the centre of the facial rays, about 250 μ long and about 20 μ thick at the base.

Triradiates of chamber layer (c) subregular or slightly sagittal, slightly irregular in outline. All rays are of subequal thickness. In a large example of the spicule, the rays measured 350 μ long and 30 μ thick.

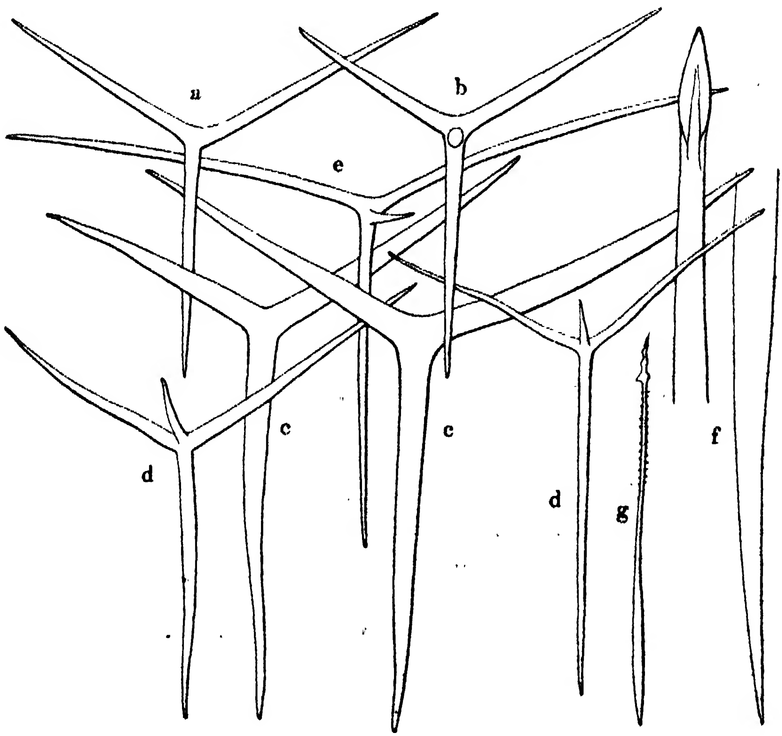
Quadriradiates of the exhalant canals (d) sagittal. Basal ray straight, longer than paired rays. Paired rays curved around the exhalant canal. Apical ray much shorter than facial rays, very slender, slightly curved. The dimensions vary fairly considerably. In a typical case the basal ray measures 300 μ by 16 μ; the paired rays about 200 μ by 16 μ, and the apical ray about 150 μ by 10 μ.

Gastral quadriradiates (e) strongly sagittal. Paired rays widely divergent, gently curved backwards, about 320 μ by 14 μ; basal ray straight, about as thick as, and usually somewhat shorter than, the paired rays, about 220 μ by 14 μ; apical ray thorn-like, usually slightly curved, finely pointed, much shorter than the facial rays, about

20 μ long.

Oxea (f) very large, cylindrical, usually gently curved, provided with a lance-head at the outer end and simply sharply pointed at the inner; they vary in size and measure up to about 2.75 mm. by 40 μ thick.

Microxea of the dermal and gastral cortices (g) are either straight or slightly curved. They are thicker at the point nearer the inner end than at the outer and taper towards both ends. The inner end is solely sharply pointed while the outer is provided with a pointed lance-head. The distal half of the spicule is beset with fine spines on its side and they are directed inwards. An example of the spicule measures about 150 μ in length and 4 μ in thickness at the



Text-fig. 13. *Leucandra pallida*, n. sp.

a, Dermal triradiate. b, Dermal quadriradiate. c, Triradiates of chamber layer. d, Quadriradiates of the larger exhalant canals. e, Gastral quadriradiate. f, Large oxea. g, Microxea. (a–f ×150; g ×300)

thickest part.

Locality and Register No. of Specimen. — Shark's Bay District (Station ?), B.

38. Leucandra phillipensis DENDY

Leucandra phillipensis, DENDY, 1892, p. 100.

The collection contains four specimens (Q, S_1, S_2IV, T) of this species. The largest specimen (Spec. No. Q) which was obtained at Station 19 in Shark's Bay is flask-like in form, being broad in the basal half and becoming narrower rather suddenly in the distal half and terminating in an open osculum, It measures about 70 mm. in total length and about 25 mm. in greatest breadth. The outer surface is uneven and is moreover thickly coated with projecting oxea. The osculum is almost circular surrounded by a thin oscular margin. The sponge-wall is about 7 mm. thick in the basal parts of the body and becomes gradually thinner towards the osculum. The colour in alcohol is greyish white and the texture is moderately firm and elastic. The remaining three specimens are much smaller and are less conspicuous in hispidity than the first specimen.

Previously known Distribution. — Near Port Phillip Heads (DENDY).

Localities and Register Nos. of Specimens. — Shark's Bay District (Station 19), Q; (Station 15), S_1, S_2IV; (Station 21), T.

39. Leucandra thulakomorpha, n. sp.

(Pl. XXI, Fig. 15; Text-fig. 14)

This new species is represented by an unique specimen in the collection (Spec. BH from Station 64).

It (Pl. XXI, Fig. 15) is tube-like but is strongly deformed presenting a peculiar appearance. It is split along one of its sides and hence most of the gastral surface is observable from the outside through the fissure. It is obvious that the said deformation is produced by some accidental injury and may not be considered as natural.

The total length of the sponge including the oscular fringe is about 70 mm. and the greatest breadth is about 35 mm. The thickness of the wall is about 8 mm. measured at the thickest part but it becomes

gradually thinner towards the osculum and both edges along which the sponge is split.

The oscular fringe is well-developed and measures about 8 mm. high.

The outer surface of the sponge is strongly hispid, owing to the presence of large oxea projecting from it. The gastral surface is perforated by numerous round apertures of varying sizes. They are rather thickly placed and measure up to 3 mm. in diameter.

The colour in alcohol is grey; the texture is rather soft.

Structure. — The canal system is of the leuconoid type. The chamber layer is strongly lacunar being traversed by thick inhalant and exhalant canals. The flagellate chambers are spherical or oval in shape with a diameter of 70–120 μ.

The dermal skeleton is made up of tangential triradiates and quadriradiates arranged in a few layers. The apical rays of the latter kind of spicule penetrate to some extent into the chamber layer. The large oxea and the hair-like oxea which occur very thickly and in nearly vertical disposition in the sponge wall project out on the dermal surface. The skeleton of the chamber layer consists chiefly of triradiates with an admixture of a few quadriradiates which are chiefly arranged along the wall of the larger exhalant canals. Some of the triradiates of the chamber layer take the subdermal position. The gastral skeleton is rather thin, being composed of quadriradiates in a few layers. The apical rays of these spicules project either into the large exhalant canals or into the gastral cavity. The skeleton of the oscular fringe is a close interlacement of triradiates and quadriradiates, both of which have strongly divergent paired rays and a downwardly directed basal ray. There may be found in addition some large oxea and hair-like oxea placed longitudinally.

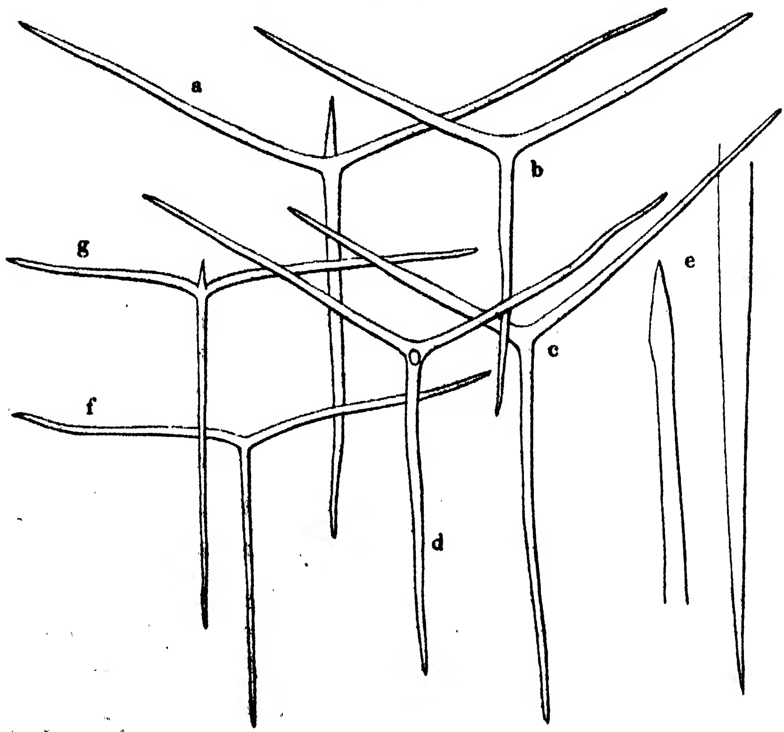
Spicules (Text-fig. 14). — Dermal quadriradiates (a). Facial rays more or less sagittal, rather slender and fairly sharply pointed, measuring about 300 μ by 16 μ. Apical ray directed centripetally, protruding into the chamber layer to some extent, and shorter than the facial rays measuring up to about 250 μ.

Dermal triradiates (b) nearly the same as the dermal quadriradiates except for the absence of an apical ray.

Triradiates of the chamber layer (c) more or less sagittal, rays rather slender, equally thick and not strongly differentiated in length. Basal ray nearly straight and the paired rays slightly curved forwards. Size variable, rays measuring about 330 μ by 16 μ.

Gastral quadriradiates (d) more or less sagittal. Facial rays rather slender, nearly equally thick. Basal ray nearly straight and the paired rays slightly curved forwards. Facial rays measuring about 350 μ by 16 μ. Apical ray rather strongly developed, curved and gradually sharp-pointed, nearly straight in basal portion and slightly curved in the apical, sometimes as long or longer than the facial rays, attaining the length of 400 μ.

Large oxea projecting from dermal surface (e) straight or slightly



Text-fig. 14. *Leucandra thulakomorpha*, n. sp.
a, Dermal quadriradiate. b, Dermal triradiate. c, Triradiate of chamber layer. d, Gastral quadriradiate. e, Large oxea projecting from dermal surface. f, Triradiate of the oscular margin. g, Quadriradiate of the same. (All ×150).

curved, and nearly uniformly thick in the greater part of their length, tapering at the ends. The outer end is provided with a feebly developed lance-head while the inner is solely sharply pointed, 3–9 mm. long and 30-40 μ thick at the thickest part.

Hair-like oxea nearly straight and uniformly thick with both ends sharply pointed. The free end is usually found broken off. A medium sized example of the spicule measured 2.4 mm. long and 5 μ thick.

Triradiates of the oscular margin (f) strongly sagittal. Basal ray straight, finely pointed, slightly longer and thinner than paired rays. Paired rays strongly diverging, nearly uniformly thick except for the sharply pointed end, slightly curved backwards in basal parts and slightly curved forwards in the remaining parts. In a typical example of the spicules the basal ray measured about 450 μ by 12 μ and the paired rays about 360 μ by 12 μ.

Quadriradiates of the oscular margin (g) exactly similar to the triradiates of the same except for the presence of an apical ray. Apical ray short, much shorter than the facial rays, usually slightly curved and gradually sharp-pointed.

Locality and Register No. of Specimen. — Albany District (Station 64), BH_2.

Remarks. — Of this new species, the presence of dermal quadriradiates with apical rays protruding though not very deeply into chamber layer remind us that it has a close affinity to some members of the genus *Leucilla* of the family Amphoriscidae.

Family **Amphoriscidae** DENDY (emend.)

Genus LEUCILLA HAECKEL (emend.)

40. **Leucilla australiensis** (CARTER)

Leuconia johnstonii var. *australiensis*, CARTER, 1886, p. 133.
Leucilla australiensis, DENDY, 1892, p. 115; DENDY and ROW, 1913, p. 783.

We have identified with this species two specimens in the collection.

The first specimen ($AW_1\alpha$) represents a small solitary person of oval form, showing at the upper end a circular osculum which is naked. It is nearly 4 mm. broad and 3 mm. high. The osculum measures 0.6 mm. in diameter. The sponge-wall is comparatively thick, measuring about 1 mm.

The second specimen ($AW_1\beta$) is of nearly equal appearance with the first, but is more or less thinner, measuring 4 mm. in breadth and 1.5 mm. in height. It is also provided with an oval osculum which is 0.6 mm. in the greater diameter.

Previously known Distribution. — Near Port Phillip Heads (CARTER and DENDY).

Locality and Register Nos. of Specimens. — Albany District (Station 63), $AW_1\alpha$, $AW_1\beta$.

41. **Leucilla lanceolata**, n. sp.

(Pl. XXI, Fig. 16; Text-fig. 15)

A single specimen of this new species exists in the collection (Spec. BQ from Station 64).

It (Pl. XXI, Fig. 16) is a solitary person of an elongate oval shape, showing a convex curvature on one side. It is about 15 mm. in length and about 7 mm. in greatest breadth.

The outer surface is strongly hispid owing to the presence of large oxea projecting from it. The osculum at the upper end is oval with a greater diameter of 2 mm. and is surrounded by a rather well-developed collar of about 1.5 mm high. The sponge-wall is thickest in the basal parts (about 1 mm. thick) but becomes gradually thinner towards the oscular margin. The gastral surface is perforated by numerous circular or oval apertures of exhalant canals of up to 300 μ diameter. It is also rough from the projecting apical rays of the gastral quadriradiates.

The colour in alcohol is greyish white and the texture is moderately elastic.

Structure. — The canal system is of the leuconoid type. Both the inhalant and exhalant canals are very wide running deep into the wall. The flagellate chambers are densely and irregularly arranged between inhalant and exhalant canals. They are either spherical or ovoid, measuring 50–160 μ across. Diaphragm is present at each apopyle.

The skeleton of the dermal cortex consists mainly of the facial rays of subdermal quadriradiates. The large oxea which occur fairly thickly in the sponge-wall project out on the dermal surface. The trichoxea also project from the dermal surface, their proximal parts

being imbedded in the chamber layer.

The skeleton of the chamber layer is made up of the apical rays of subdermal quadriradiates, triradiates arranged in several confused layers with their basal rays in most cases pointing centrifugally and the basal rays of subgastral triradiates. Along the larger exhalant canals there occur some quadriradiates with apical ray projecting into the canal.

The skeleton of the gastral cortex is composed of tangentially placed quadriradiates and of the paired rays of subgastral triradiates.

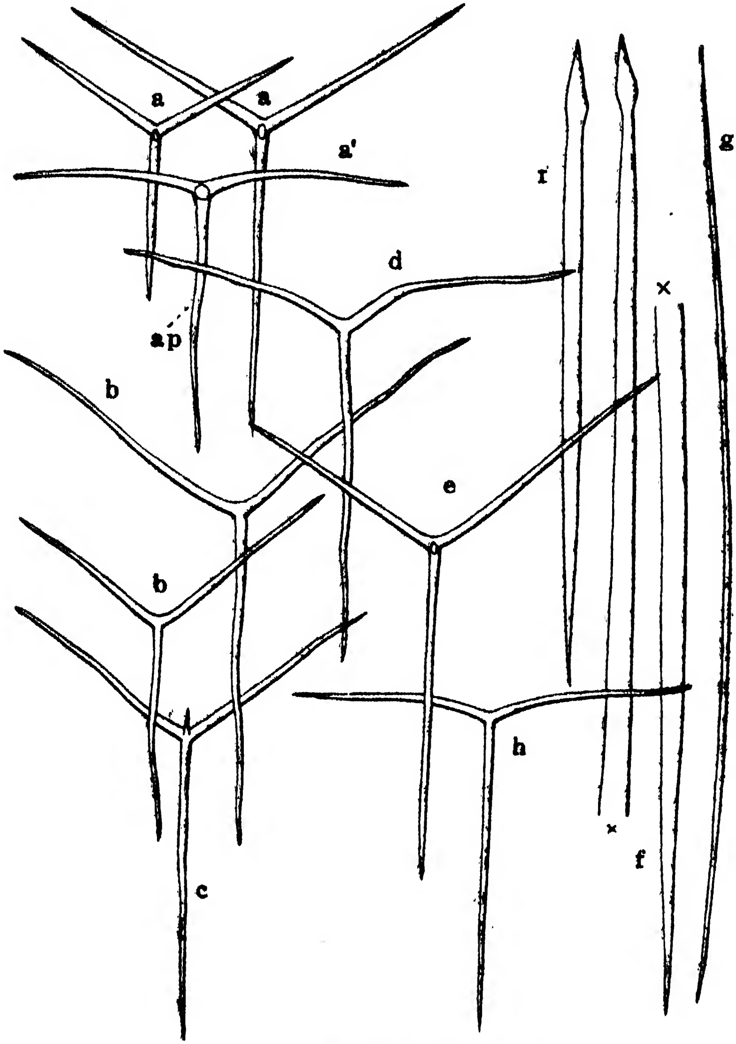
The skeleton of the oscular margin is a close interlacement of triradiates and quadriradiates, both of which have strongly divergent paired rays and a downwardly directed basal ray. There may be found in addition some large oxea disposed parallel to the long axis of the sponge.

Spicules (Text-fig. 15). — Subdermal quadriradiates (a) slightly sagittal in most cases. Basal ray generally longer than the paired rays, nearly straight, gradually and sharply pointed, 260–340 μ long and 14–16 μ thick at the base. Paired rays nearly as thick as basal ray, almost straight except for the slight curvature at the base, gradually and sharply pointed, 200–300 μ long and 14–16 μ thick at the base. Apical ray nearly as long as paired rays, straight or slightly curved, sharply pointed at the end, 200–340 μ long and 14–16 μ thick at the base.

Triradiates of chamber layer (b) slightly sagittal. Rays rather slender and more or less irregular in outline. Basal ray longer than paired rays, usually straight but sometimes more or less crooked, 300–440 μ long and 10–14 μ thick at the base. Paired rays nearly as thick as the basal ray, slightly doubly curved, forwards in basal parts and backwards in the remaining parts, 240–360 μ long and 10–14 μ thick at the base.

Quadriradiates of the larger exhalant canals (c) exactly similar to the triradiates of the chamber layer except in the presence of an apical ray. Apical ray much shorter and slightly thinner than the facial rays, slightly curved and gradually and sharply pointed, 60 μ long and about 8 μ thick at the base.

Subgastral triradiates (d) sagittal, nearly similar to the triradiates of the chamber layer but with oral angles much wider. Basal ray



Text-fig. 15. *Leucilla lanceolata*, n. sp.

a, Subdermal quadriradiates. a′, The same showing the apical ray (ap). b, Triradiates of chamber layer. c, Quadriradiate of the larger exhalant canal. d, Subgastral triradiate. e, Gastral quadriradiate. f, Large oxea projecting from dermal surface. g, Trichoxea projecting from dermal surface. h, Triradiate of oscular margin. (All ×110)

slightly longer than paired rays, straight or slightly crooked, finely pointed at the end, about 440 μ long and 14 μ thick at the base.

Paired rays as thick as basal ray, strongly diverging, more or less angularly curved at a point a short distance from the base, about 300 μ long and about 14 μ thick at the base.

Gastral quadriradiates (e) slender rayed, slightly sagittal. Facial rays not strongly differentiated in length and of nearly equal thickness. Basal ray nearly straight, finely pointed, about 400 μ long and 12 μ thick at the base. Paired rays subequal in length, usually doubly curved, first forwards and then backwards, sharply pointed at end, about 340 μ long and 12 μ thick at the base. Apical ray nearly as thick as the facial rays but slightly shorter. It is slightly curved and sharply pointed, 200–300 μ long and about 12 μ thick at the base.

Large oxea projecting from dermal surface (f) straight or slightly curved, nearly uniformly thick throughout their greater length, provided with a lance-head at the distal end and solely sharply pointed at the proximal end. A small example of the spicule measured 1 mm. long and 20 μ thick; a large one 3.5 mm. long by 40 μ thick.

Trichoxea projecting from dermal surface (g) straight or slightly curved, and nearly uniformly thick in the greater part of their length, though tapering at the ends which are finely pointed. A large example of the spicule measured 1 mm. long and 4 μ thick.

Triradiates of oscular margin (h) sagittal. Basal ray usually longer and thinner than paired rays, straight, very finely pointed at the end. Paired rays strongly diverging, nearly uniformly thick for their greater length and sharply pointed at the end. They are slightly and gently curved backwards in their basal parts and either straight or slightly curved forwards in the remaining parts. In an example of the spicule, the basal ray measured 400 μ long and 10 μ thick at the base, and the paired rays 240 μ long and 12 μ thick.

Quadriradiates of the oscular margin are like the triradiates of the same, except in the presence of an apical ray. Apical ray much shorter than the facial rays, never attaining so great a length as in the gastral quadriradiates.

Large oxea of the oscular margin exactly the same as those projecting from the dermal surface.

Locality and Register No. of Specimen. — Albany District (Station 64), BQ.

42. Leucilla princeps, n. sp.

(Pl. XXI, Fig. 17; Text-fig. 16)

This new species is based on five specimens in the collection.

The first specimen (AQ_2a from Station 36) which is herewith made the type of the species, is a single person of a somewhat curved elongate cylindrical form, broadest at a part a little below the middle. The total length is about 40 mm. and the greatest breadth is about 5 mm. Thickness of the wall, as measured in the broadest part is about 1.5 mm. It becomes thinner towards the osculum. The osculum at the upper end is circular, with a diameter of about 2 mm. It is surrounded by a thin oscular margin but is deprived of a well-defined fringe of oxea. The dermal surface is more or less hispid due to the projecting oxea. The gastral cavity is deep and extends throughout the entire length of the sponge. The gastral surface is rough from the projecting apical rays of the gastral quadriradiates.

The colour in alcohol is greyish white and the texture is fairly firm.

The second specimen (AQ_4a from Station 36; Pl. III, Fig. 17) is much smaller than the type-specimen, measuring about 22 mm. in length and 4 mm. in greatest breadth. The osculum is oval with the greater diameter of 1.5 mm. and is provided with a well-developed fringe of oxea of about 2 mm. high.

Structure.— The canal system is of the leuconoid type. The chamber layer is strongly lacunar, being traversed by well-developed inhalant and exhalant canals. Between these canals are thickly packed together ovoid spherical flagellate chambers of 50–140 μ diameter.

The dermal skeleton is composed of triradiates, the facial rays of subdermal quadriradiates, large oxea and trichoxea. The triradiates lie tangentially in a very thin layer in a rather confused arrangement. The facial rays of the subdermal quadriradiates are tangentially placed without any definite orientation. The large oxea which occur here and there in the sponge-wall project out on the dermal surface at varying angles. Those spicules found near the osculum run almost parallel to the long axis of the sponge. The trichoxea which are rather sparcely distributed project nearly vertically from the dermal surface.

The skeleton of the chamber layer is made up of the apical rays of subdermal quadriradiates as well as of quadriradiates in a few irregular layers. The basal rays of the latter point centrifugally and the apical rays project into the exhalant canal. The basal rays of subgastral quadriradiates may be added to the skeleton.

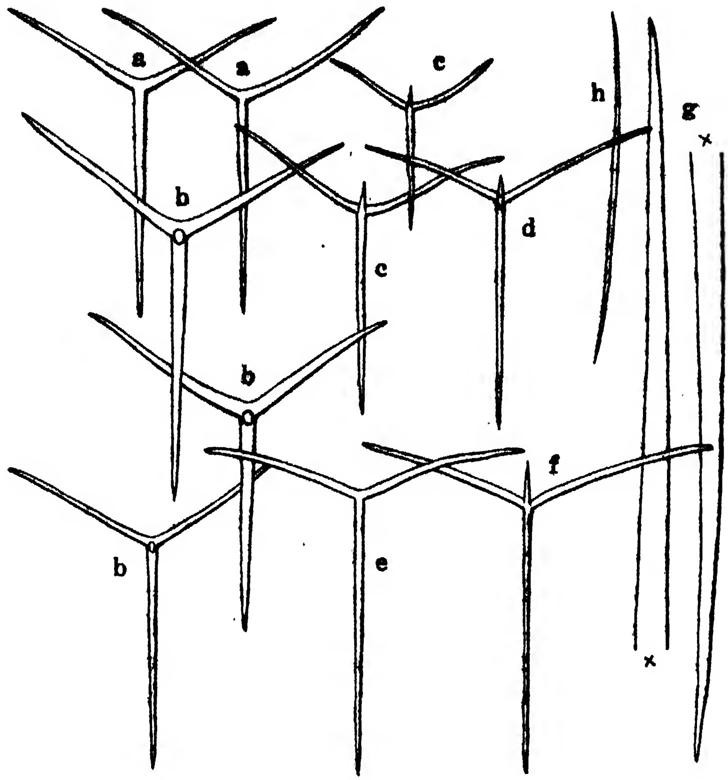
The skeleton of the gastral cortex forms a thin layer consisting of gastral quadriradiates with apical rays projecting into the gastral cavity. In addition to the quadriradiates there occur in the layer the facial rays of subgastral quadriradiates.

The skeleton of the oscular margin is an interlacement of trichoxea, triradiates and quadriradiates. The trichoxea are arranged longitudinally; the basal rays of the tri- and quadriradiates are directed regularly downwards.

Spicules (Text-fig. 16).—Dermal triradiates (a) slightly sagittal with basal ray a little longer than the paired rays. All rays are of equal thickness. Paired rays slightly curved forwards, often somewhat crooked, sharply pointed, about 200 μ long and 12–16 μ thick at the base. Basal ray straight, gradually and sharply pointed, about 240 μ long and 12–16 μ thick at the base. These spicules become much more sagittal towards the oscular margin.

Subdermal quadriradiates (b) almost like the dermal triradiates with the addition of an apical ray, but on the whole stouter. Basal ray slightly longer than paired rays, straight, gradually tapering, sharply pointed, about 260 μ long and 12–20 μ thick at the base. Paired rays slightly curved forwards, gradually and sharply pointed, about 180 μ long and 10–20 μ thick at the base. Apical ray not strongly differentiated in length from the facial rays, nearly straight, often somewhat crooked, gradually and sharply pointed, 180–280 μ long and 12–20 μ thick at the base.

Quadriradiates of chamber layer (c) slender. Facial rays sagittal in most cases. Basal ray longer than paired rays, nearly straight, often more or less crooked, gradually sharp-pointed, 200–260 μ long and 12–18 μ thick at the base. Paired rays nearly equally as thick as the basal ray, usually curving first forwards and then slightly backwards, 120–200 μ long and 12–18 μ thick at the base. Apical ray much shorter than the paired rays, straight or slightly curved, sharply pointed, 40–60 μ long.



Text-fig. 16. *Leucilla princeps*, n. sp.
a, Dermal triradiates. b, Subdermal quadriradiates. c, Quadriradiates of chamber layer. d, Gastral quadriradiate. e, Triradiate of oscular margin. f, Quadriradiate of the same. g, Large oxea projecting from dermal surface. h, Trichoxea projecting from dermal surface. (All ×110).

Subgastral quadriradiates nearly similar to the quadriradiates in the chamber layer, differing only in having a wider oral angle.

Gastral quadriradiates (d) slender-rayed. Facial rays slightly sagittal in most cases, the basal ray being longer than paired rays. Basal ray straight, fairly sharply pointed, 140–230 μ long and 10–12 μ thick at the base. Paired rays widely diverging, gently curved backwards, 100–200 μ long and 10–12 μ thick at the base. Apical ray generally longer than both the basal and paired rays, slightly curved, nearly uniformly thick through its greater length and sharply pointed at the end, 180–450 μ long and 8–12 μ thick at the base.

Triradiates of the oscular margin (e) sagittal. Basal ray straight, nearly uniformly thick for its greater length, sharply pointed, about 360 μ long and about 10 μ thick at the base. Paired rays usually slightly shorter and thicker than the basal ray, slightly curved backwards, strongly diverging, nearly uniformly thick for the greater of their length and sharply pointed at the end, about 200 μ long and 12 μ thick at the base.

Quadriradiates of oscular margin (f) exactly similar to the triradiates of the same but with a short apical ray about 50 μ long and 6 μ thick at the base.

Large oxea projecting from the dermal surface (g) elongate spindle-shaped, usually slightly curved, sharply pointed at both ends. A medium-sized example of the spicule measured 1.8 mm. long and 40 μ thick.

Trichoxea projecting from the dermal surface (h) straight or slightly curved, 300–600 μ long and 2–4 μ thick.

Trichoxea of oscular margin nearly like those projecting from the dermal surface. The free end is found broken in the type-specimen.

Locality and Register Nos. of Specimens. — Fremantle District (Station 36), $AQ_2\alpha$, $AQ_4\alpha$, $AQ_4\beta$, $AQ_4\gamma$; (Station 37), AS_1.

43. **Leucilla oblata,** n. sp.

(Pl. XXI, Fig. 18; Text-fig. 17)

This new species is based on five specimens in the collection.

The first specimen (Spec. N_2 from Station 15), which we make the type of the species, forms an irregularly shaped mass of branching and anastomosing tubes with a height of 35 mm., breadth of 55 mm. and thickness of about 35 mm. Some of these tubes are blind while the others are provided with an osculum at their free end. One of the medium-sized tubes measured about 6 mm. in diameter and about 1.5 mm. in the thickness of the wall. The osculum is naked and circular or elliptical in outline. It is surrounded by a very thin wall. The dermal surface of the sponge is smooth; the gastral surface is perforated by numerous exhalant apertures which are irregularly distributed and are of varying sizes, measuring 0.3–0.8 mm. across.

The colour in alcohol is white with a somewhat greyish tint. The texture is rather compact and pretty hard.

The second specimen (Spec. N_1 from Station 15) consists of a main tube and several smaller secondary tubes which budded out from the first. The main tube is irregularly curved and slightly laterally compressed. It measures about 45 mm. long by 8 mm. broad at the middle part where the wall is about 1.5 mm. thick. The terminal osculum is irregular in outline measuring about 2.5 mm. across. The secondary tubes are partly blind and partly provided with an osculum at the free end. They measure from 4 to 9 mm. in length and from 2 to 5 mm. in breadth.

The remaining three specimens (Spec. Nos. B_8, S_2II, U) are nearly the same in external features, each of them being a solitary person of more or less curved and laterally compressed tubular shape. The osculum exists at the upper end of the tube. They are much smaller than the specimens above mentioned and are under 10 mm. in length. The following descriptions refer to the type-specimen.

Structure. — The canal system is of the leuconoid type. Both the inhalant and exhalant canals are very wide and extend through the greater part of the wall thickness. The flagellate chambers vary in shape and size, from those of spherical shape measuring about 100 μ in diameter to others of elongate sac-like configuration, say, 200 μ by 100 μ in dimension. They are rather loosely set in the chamber layer between the inhalant and exhalant canals.

The dermal skeleton consists of triradiates, facial rays of subdermal quadriradiates and hair-like oxea. The triradiates lie parallel to the dermal surface and are arranged in a few layers without any definite orientation. The facial rays of the subdermal quadriradiates also lie parallel to the dermal surface but in rather confused orientation. A few hair-like oxea lie in the dermal cortex at nearly a vertical angle to the external surface, beyond which their outer portions freely project to a certain extent.

The skeleton of the chamber layer is formed by the centripetal apical rays of subdermal quadriradiates and of the centrifugal basal rays of subgastral triradiates to which there may be added a small number of the centrifugal basal rays of subgastral quadriradiates.

The gastral skeleton is made up chiefly of the paired rays of subgastral triradiates and the gastral quadriradiates, to which a small number of the facial rays of subgastral quadriradiates may be added.

The gastral quadriradiates are tangentially placed without definite orientation and are arranged in a few layers. The short apical rays project into the gastral cavity.

The oscular margin is composed of very closely set triradiates, which have very strongly divergent paired rays. There may be added some number of hair-like oxea running longitudinally and parallel with one another.

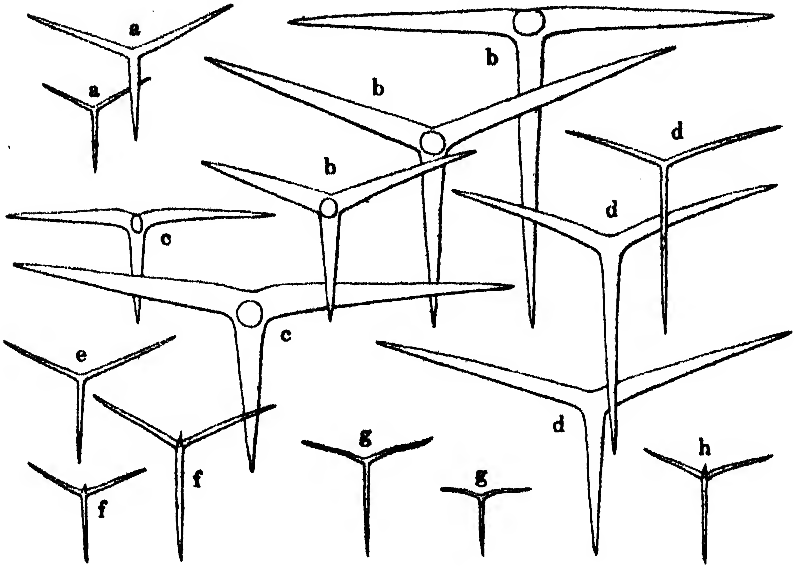
Spicules (Text-fig. 17). — Dermal triradiates (a) generally slightly sagittal, the oral angle being greater than in the paired ones. All rays are of equal thickness. The basal ray is, as usual, slightly shorter than the paired rays, quite straight, gradually and sharply pointed, 160–200 μ long and 10–18 μ thick at the base. The paired rays are nearly equal, 200–300 μ long and 10–18 μ thick at the base.

Subdermal quadriradiates (b) large and very stout, with gradually and sharply pointed straight rays of nearly equal thickness. The oral angle is greater than in the paired angles. The basal ray is shorter than the paired rays, being 300–500 μ long and 40–60 μ thick at the base. Paired rays generally equally long but sometimes slightly differentiated in length, 480–700 μ long and 40–60 μ thick at the base. Apical ray usually longer than either of the basal or paired rays, 600–800 μ long and 40–60 μ thick at the base.

Subgastral quadriradiates (c) large and stout. All rays are of nearly equal thickness and gradually sharp-pointed. Basal ray straight, generally shorter than the paired rays but sometimes nearly equally as long as they, 260–380 μ long and 40–80 μ thick at the base. Paired rays subequal, slightly curved at the base and nearly straight in the remaining portion, very widely diverging and standing out almost at right angles from the basal ray, 350–660 μ long and 40–80 μ thick at the base. Apical ray nearly as long as the facial rays.

Subgastral triradiates (d) slightly sagittal, the oral angle being wider than in the paired ones. All rays equally thick, but often slightly irregularly contoured and gradually tapering to a sharp point. Basal ray nearly straight, 300–500 μ long and 20–60 μ thick at the base. Paired rays subequal in length, slightly curved backwards, 260–640 μ long and 20–60 μ thick at the base.

Gastral triradiates (e) slightly sagittal. All rays rather slender, not strongly differentiated in length, equally thick, often slightly



Text-fig. 17. *Leucilla oblata*, n. sp.
a, Dermal triradiates. b, Subdermal quadriradiates. c, Subgastral quadriradiates. d, Subgastral triradiates. e, Gastral triradiate. f, Gastral quadriradiates. g, Triradiates of oscular margin. h, Quadriradiate of the same. (All about $\times 50$)

irregular in outline, tapering to a sharp point. Basal ray straight, about 250 μ long and 20 μ thick at the base. Paired rays nearly straight or slightly curved forwards, about 280 μ long and 20 μ thick at the base.

Gastral quadriradiates (f) similar to the gastral triradiates, differing only in the presence of an apical ray. Apical ray much shorter and thinner than the facial rays, tapering and sharply pointed, slightly curved, 30–60 μ long and 8–14 μ thick at the base.

Triradiates of the oscular margin (g) sagittal. Basal ray usually longer and thinner than paired rays, quite straight, sharply pointed, 120–240 μ long and 8–12 μ thick at the base. Paired rays strongly divergent, slightly curved backwards in basal parts and either straight or slightly curved forwards in the remaining parts, nearly uniformly thick for the greater part of their length, more or less irregular in outline, 100–180 μ long and 10–14 μ thick at the base.

Quadriradiadiates of the oscular margin (h) nearly similar to the

triradiates of the same but with a short apical ray. Apical ray slightly curved and sharply pointed.

Hair-like oxea of the oscular margin straight or slightly curved, about 280 μ long and 2 μ thick.

Hair-like oxea of the dermal cortex rather short and seeming to be intermediate between the microxea and trichoxea.

Locality and Register Nos. of Specimens.—Shark's Bay District (Station ?), B_3; (Station 15), N_1, N_2, S_2II; (Station 21), U.

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EXPLANATION OF THE PLATES.

PLATE XIX.

Fig. 1. *Leucosolenia psammophila*, n. sp. about ×1.
Fig. 2. *Leucosolenia vitraea*, n. sp. about ×5.
Fig. 3. *Leucetta insignis*, n. sp. ×1½.
Fig. 4. *Leucetta infrequens*, n. sp. ×2.
Fig. 5. *Leucetta expansa*, n. sp. ×1.
Fig. 6. *Leucettusa dictyogaster*, n. sp. ×1¼.

PLATE XX.

Fig. 7. *Sycon carteri* DENDY about ×2.
Fig. 8. *Sycon enciferum* DENDY ×5.
Fig. 9. *Sycon lendenfeldi*, n. sp. ×5.
Fig. 10. *Sycon minutum* DENDY ×5.
Fig. 11. *Vosmaeropsis dendyi*, n. sp. ×7.
Fig. 12. *Grantia genuina*, n. sp. ×5.

PLATE XXI.

Fig. 13. *Leucandra minima*, n. sp. ×5.
Fig. 14. *Leucandra pallida*, n. sp. ×3.
Fig. 15. *Leucandra thulakomorpha*, n. sp. ×1.
Fig. 16. *Leucilla lanceolata*, n. sp. ×3¼.
Fig. 17. *Leucilla princeps*, n. sp. ×5.
Fig. 18. *Leucilla oblata*, n. sp. ×4.


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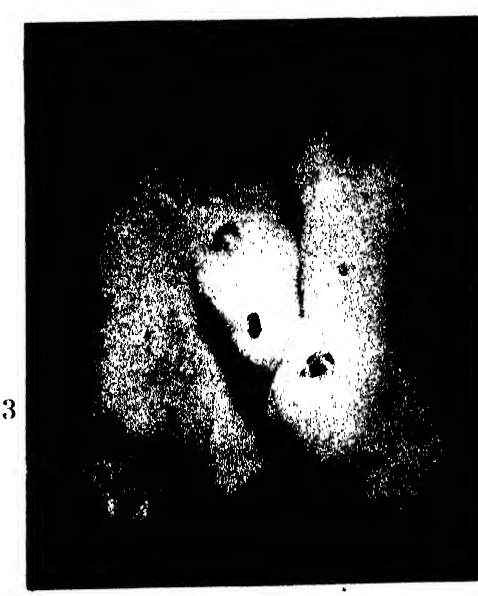
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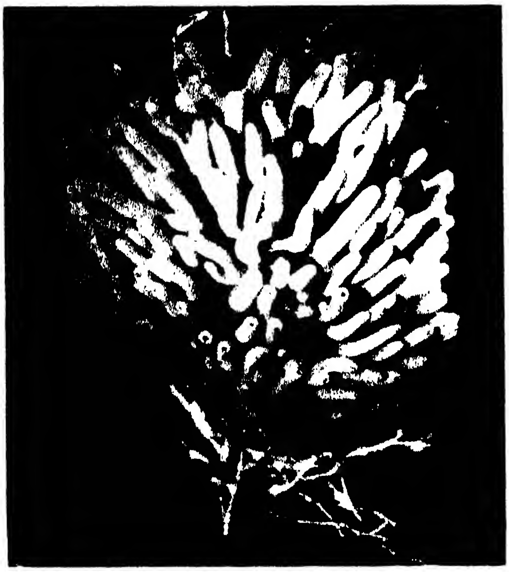

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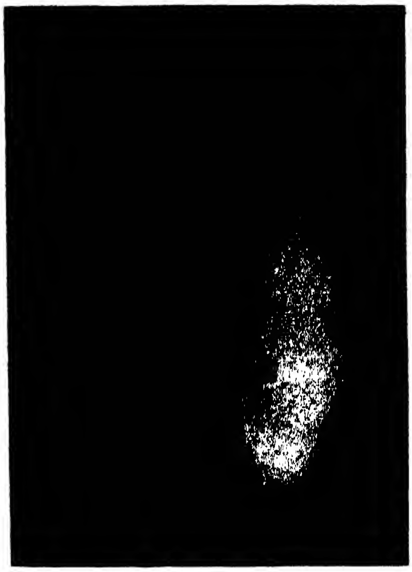

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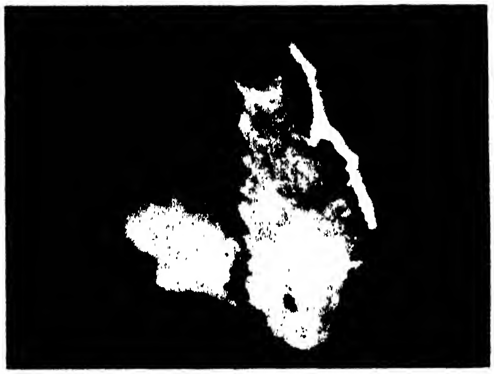

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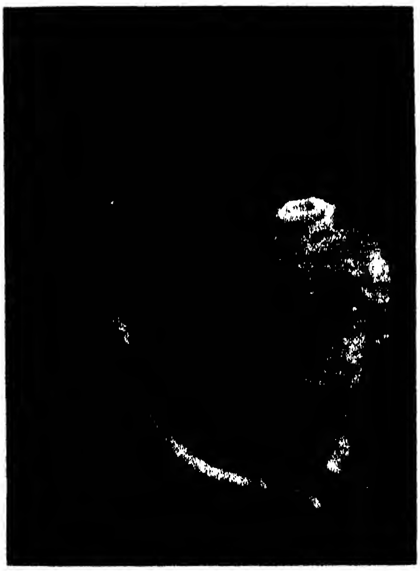

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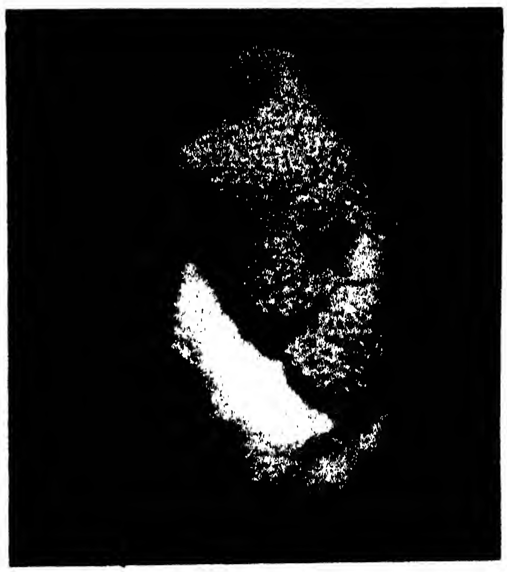

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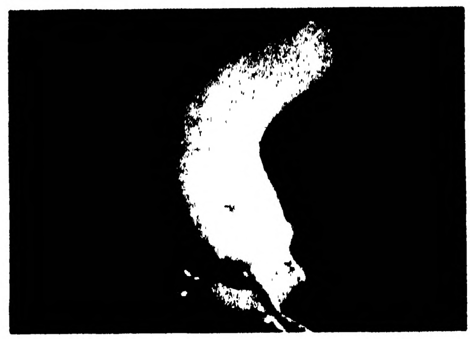

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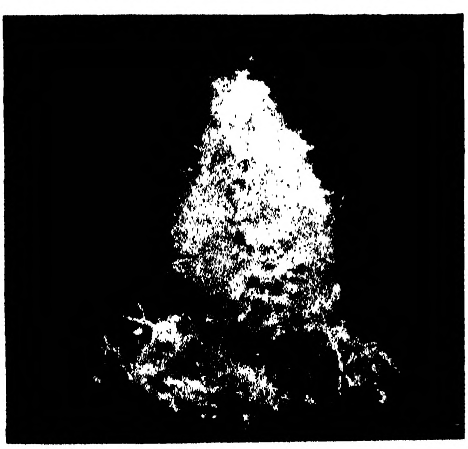

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